FACTORY DEPARTMENT
MINISTRY OF LABOUR AND NATIONAL SERVICE

INDUSTRIAL LUNG DISEASES OF IRON AND STEEL FOUNDRY WORKERS

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Industrial Lung Diseases of Iron and Steel Foundry Workers

An investigation of 3,059 workers in 19 foundries together with an analysis of the records of lung diseases in foundry workers in the files of the Factory Department and the Silicosis and Asbestosis Medical Board, pathological investigations of the lungs of 64 foundry workers and dust surveys in three foundries

BY

A I G McLAUGHLIN M B Ch M F R C P [1]

with the assistance of

E A CHEESEMAN Ph D B Sc [3] [7]

JESSIE GARRAD B Sc [7]

S ROODHOUSE GLOYNE M D D P H [4]

K L GOODALL M Sc F Inst P [1]

H E HARDING D M [5]

M H JUPE F R C S D M R E F F R [2]

W B LAWRIE M Sc [1]

K M A PERRY M D F R C P [2]

C L. SUTHERLAND O B E M D D P H D I H [6]

H WOODS B Eng [ ]

[1] Factory Department Ministry of Labour and National Service

[2] London Hospital

[3] Department of Social and Preventive Medicine Queen s University of Belfast

[4] London Chest Hospital and Institute of Social Medicine Oxford

[5] Department of Pathology University of Sheffield

[6] Silicosis and Asbestosis Medical Board [now under the Ministry of National Insurance]

[7] Formerly on the staff of the Medical Research Council

INTRODUCTION

Some time ago the Chief Inspector of Factories asked the Medical Branch of the Inspectorate to carry out some further investigations as to lung affections among workers in iron and steel foundries with a view to throwing further light on the relative incidence and seriousness of such affections in relation to different occupations or processes in such foundries These investigations were primarily entrusted to Dr McLaughlin one of the Medical Inspectors

The investigations developed into a very substantial piece of work and the assistance of various other experts was successively enlisted The result has been the production of this Report which contains a great deal of information of scientific value which enlarges our knowledge of the incidence risk and nature of the lung affections to which such foundry workers are exposed in the course of their varied occupations

To H. M. Chief Inspector of Factories

IN RECENT YEARS there has been a quickening of interest in the health and welfare of iron and steel foundry workers. During the 1930's both the Factory Department and the Silicosis and Asbestosis Medical Board noticed an increasing number of cases of silicosis amongst fettlers of steel castings. A clinical and radiographic investigation made in 1943 of the workers in one steel foundry revealed a high incidence of severe lung trouble amongst the fettlers whereas the moulders' lungs were comparatively little affected. About the same time the occurrence of three deaths from silicosis in a small group of iron moulders who had been using silica parting powders drew attention to the risk which such workers run. It was then decided to examine more workers in both iron and steel foundries in different parts of the country to see if the risks are general to the industry, though good prima facie evidence that they are had been obtained by analysis of the records of the Factory Department, the Silicosis and Asbestosis Medical Board and the Registrar General's Department. In the field investigation much help was given by the London Hospital Department for Research in Industrial Medicine (Medical Research Council) and in fact the expenses of the radiographic examinations were defrayed by the Council.

Owing to the fact that all the investigators could devote only a small portion of their time to the work, the inquiry took a good deal longer than expected and as it developed its scope widened and more workers were co-opted. Dr M. H. Jupe, radiologist to the London Hospital, was asked to help with the interpretation of the X-ray films, Dr E. A. Cheeseman with the statistical side of the inquiry, Dr S. Roodhouse Gloyne and Dr H. E. Harding with the pathology, and Dr C. L. Sutherland agreed to add the valuable information about foundry workers contained in the records of the Silicosis and Asbestosis Medical Board. The statisticians were called in after the field work had been completed and the original investigators were criticized on that account and also because no strict sampling methods were used. The aim of the field investigators has been to get as many volunteers as possible to present themselves for examination. It has been their experience in dealing with factory

workers that if one man is chosen for examination rather than another, suspicion is aroused in the workers' minds and results usually in fewer people coming for examination In practice the "all or none" method appears to work better than sampling but it also produces varying percentages of volunteers from different factories which from a statistical point of view are undesirable

Dr Cheeseman has closely analysed the results of the field investigation On the assumption that the samples are representative of the populations from which they are drawn – which in the view of the field investigators is justified – important conclusions have been drawn about the incidence of lung disease in the various categories of workers

The statistical method is indispensable in any large-scale investigation but because it ignores the illuminating case or cases it has to be supplemented by studies of individuals For this reason it is thought that the pathological investigations recorded in Chap V are of great value The cases have been collected over a period of ten years from different parts of the country No previous report on the pneumoconioses of foundry workers has included pathological studies

Dust estimations in the foundries visited in the field survey had been planned to proceed with the clinical and radiographic examinations but for various reasons it was not possible to complete them To give some idea of the dust concentrations encountered in iron and steel foundries Mr K L Goodall of the Factory Department was therefore invited to contribute two chapters on the subject

The report brings together as much as possible of the available information about the industrial lung diseases of iron and steel foundry workers and it may be regarded as the starting point for more detailed studies of the various problems which have been brought to light

A I G McLAUGHLIN

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CHAPTER I

REVIEW OF LITERATURE

BY A I G McLAUGHLIN

That men are exposed to particular diseases from the occupations which they

the other health risks

The early writers on occupational d seases dealt mainly with the risks of mining with incidental references to foundry work Hippocrates (450 3

miner)

of the l

in Pliny

worn as respirators by metal refiners to avoid inhalat on of dust Other ancient

to which his work in the mines and foundries is said to have contributed He described the chronic lung diseases of miners as pulmonary consumpt on and asthma and while he attributed these diseases mainly to the influence of astral bodies he recognised that mineral emanations and the climate of

refer to dust

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He pointed

out that in the Carpathian mountains there were women who had married seven

husbands "all of whom th
He also referred to the u
these observations as ind
certain "corrosive" dusts
contract the disease. Nic
describe a case of phth
furnace Van
dust as a kind

F ... or to the aetiology ... and metal founders but added little to pneumonia of miners and metal founders. Leonardus Ursinus(9) wrote in 1652 groups, those arising from various metal fumes and those affected humours The principal symptoms of miners' disease were cough, and asthma and the main contributory factors were dust inhalation, strain and trauma

Samuel Stockhausen,(10) a doctor at the Goslar mines with over experience refers in a book (1649) to metal disease and miners' phth visited foundries and went down mines to supervise workers' health an exposed himself to the inhala ... the factors responsible atmospheric condition so abundant that it co of material" over the pression in the chest, a ... persistent irritating cough with marked ness of the voice The condition tended to degenerate into consump death Usually these symptoms were accompanied by others due to poisoning Diemerbroeck,(11) also in 1649, was the first to carry out an a on a case of what we now know as silicosis ... text book on occupational di of examinations of diseased of sand, that in running the he was cutting some sandy writer after Diemerbroeck to emphasise the importance of dust as the ca pulmonary disease and referred to workers engaged in pouring and re metal – idem artificibus, qui circa metalla caedenda et purificanda versa contingere constat Quemadmodum, autem hic aer quibusdam vici vaporibus et fumis inficitur, ita aliquorum locorum totus aer infectus dem in plurimos agat"* William Buchan(12) in his book Domestic (1782) wrote that "chymists, founders, forgers, glassmakers and severa artists are hurt by the unwholesome air which they are obliged to breathe air is not only loaded with noxious exhalations arising from metals and m but is so charged with phlogiston as to be rendered unfit for expandin lungs sufficiently, and answering the other important purpose of Hence proceed asthmas, coughs ... persons who follow these em "it may seem romantic to towns, but observation prove Sheffield, in Yorkshire, where iron-manufacture is carried on,

* It is agreed that the same thing happens to workmen ... metals Not only is the air adjacent [to these processes] co ... and fumes but in some places the whole air is polluted ir ... are affected

The only dust given a "clean bill of health" was graphite and he appeared to underestimate the dangers of grinding and sandblasting E L Middleton 1923([43]) in England carried out the first large scale investigation into the chest conditions of foundry workers During a general enquiry directed especially into the health of metal grinders using sandstone wheels, he included in the survey examinations of 201 dressers of steel castings and found that 22 8 per cent had pulmonary fibrosis and 6 per cent had suspected and definite tuberculosis Middleton s work was done without the help of X-ray and bacteriological examinations his conclusions being made from clinical studies In comparison, a group of 495 wet sandstone grinders showed 73 per cent of

... Nevertheless when the silicosis ...
... but not iron dressers) ...
... silicosis Middleton found that 3 types of pulmonary disease were associated with the inhalation of dust from metal grinding and the cleaning of castings, viz pulmonary fibrosis, bronchial catarrh and bronchitis

Denet Kravitz([24]) quoted by Langelez (q v) read a paper at a meeting in Belgium in 1920 during which he described the X ray appearances of the lungs of a number of castings cleaners (dessableurs) from a large foundry The films

of 11 castings cleaners came to the conclusion that ... the dust was necessary Lindau (1932)([28]) contested this opinion which he ... and described the results of his exam... findings negative and they ... spectively In 16 of these ... had tuberculosis as well ... rs it was not possible to ... Between 1918

to have silicosis and 8 per cent had open tuberculosis Those engaged on steel castings were more severely affected than dressers of iron castings, of 44 iron dressers 7 had 2nd or 3rd grade silicosis and of 56 steel dressers 18 had the

longed use of pneumatic tools with a greater production of fine dust He was of the opinion that castings cleaning (both iron and steel) should be added to the list of injurious occupations because severe cases of silicosis and silicotuberculosis occurred amongst the workers Pancoast and Pendergrass (1933)[30] described the case of an American steel moulder who, after 15 years exposure showed slight X ray changes resembling silicosis Evang (1933)[31] in Norway also reported the presence of silicosis stage 2 in a steel moulder who had worked in the job for 43 years

per cent

In 1934 the Massachusetts Industrial Disease Commission[33] examined 1 641 men from 10 foundries (steel, iron and non ferrous), 8 8 per cent of them

granite workers the frequency of silicosis (with and without tuberculosis) was positively correlated with the duration of exposure to dust containing free silica and with the concentration of dust particles in the working atmosphere

was the greatest occupational risk in the foundry industry in Massachusetts Proportionate mortality studies showed that the tuberculosis mortality rate of foundrymen is 50 per cent higher than that amongst males of 20 years and over but that the pneumonia mortality rate was three times greater than in granite workers or in the general population McConnell and Fehnel[35] in 1934 examined 215 workers in grey iron malleable iron and steel foundries Of the

Kuroda (1935)(37) examined 715 workers in Japanese foundries, X raying 314 of them, 25 ... d 2 tuberculosis Du ... ises became totally in ... It

In 1936 Merewether(38) surveyed the silicosis risk in sand and shot blasters

with tuberculosis, the average duration of employment of sandblasters was 8 3 years, as compared with 32 years for all silicosis producing occupations Bloomfield and Greenburg (1933)(39) had shown earlier that the air in a sand

... were not taken

... the dust counts rose ... cent but many of ... e with more than ... ent of those who had worked 21 years had silicosis Forty four per ce... of those workers ... of fibrosis There appeared

found 10 cases with silicosis Stage 1, 13 with Stage 2 and 6 with Stage 3 of the disease

practically no foundry process from which the dust cannot be reduced to a safe level

Another important study is that of Greenburg, Siegal and Ross Smith (1938)([48]) These workers reviewed the conditions at all the 311 foundries in New York State and examined by X ray 4,754 employees in 80 foundries, consisting of 40 iron, 3 steel and 17 non-ferrous foundries together with 20 in which combinations of several kinds of metal were cast Of 1,960 iron foundry workers 4 7 per cent had fibrosis and 3 7 per cent had silicosis, in the non-ferrous foundries (360 workers) 2 2 per cent had fibrosis and 2 8 per cent silicosis In the combined types (1,399 workers) 4 6 per cent had fibrosis and 2 4 per cent had silicosis As regards the health risk in specific foundry occupations the following details have been taken from the paper —

Moulders	1,409	4 4 per cent had	silicosis
		7 2 ,, , ,	fibrosis
		0 7 ,, ,, ,,	tuberculosis
Chippers (Fettlers)	224	4 8 per cent had	silicosis
		4 0 ,, ,, ,	fibrosis
		0 9 ,, ,, ,,	tuberculosis
Knock-out Labourers	209	0 5 per cent had	silicosis
		2 8 , ,, ,	fibrosis
		1 0 ,, ,, ,,	tuberculosis
Coremakers	492	0 8 per cent had	silicosis
		1 2 ,, ,, ,,	fibrosis
		0 8 ,, ,, ,,	tuberculosis
Grinders	277	3 7 per cent had	silicosis
		4 9 , ,, ,,	fibrosis
		0 4 ,, ,, ,,	tuberculosis
Labourers	477	1 7 per cent had	silicosis
		3 3 , ,	fibrosis
		0 4 , ,	tuberculosis
Steel blast Operators	31	3 2 per cent had	silicosis
Welders	17	5 9 per cent had	silicosis

It will be seen that welders showed the highest percentage of silicosis but we suggest that the condition was probably siderosis and not silicosis Welders

per cent fibrosis) Neither silicosis nor fibrosis was found in 24 core foremen, 4 acetylene welders and 3 sand and steel cleaners The incidence of silicosis

bricklayer

length of exposure was 35 8 years

Schiotz (1940)([53]) X-rayed 281 workers with more than 10 years exposure … and found that about 30 per cent of them had signs of

per cent) had

dressers (sand

2 of 15 core-

furnacemen,

melters, cranedrivers and sandmixers, 9 had silicosis Only 2 of 24 labourers showed signs of the disease The one sandblaster examined had a normal X-ray film

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bourers

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moulders, especially those who worked at benches … silicosis was evidently the silica flour and tripoli used as parting powders In the steel industry where wet parting methods are used, 53 per cent of the silicosis awards were to cleaning room labourers

and non-

kers in Swedish iron and

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(3) *Knock-out men* Of 15 such workers, 12 had no silicosis, while 3, who had been employed for 12 – 18 years, had Stage 1 *silicosis*

(4) *Castings cleaners* 183 were X rayed and 88 were normal, 14 had suspected silicosis 49 silicosis Stage 1 16 Stage 2 and 16 Stage 3 All such workers after 20 – 30 years exposure had the disease In one case the progress of silicosis was so rapid that he had developed 3rd Stage silicosis after 4 years Before beginning the work he had had a normal chest radiograph

(5) *Various workers in the fettling shop* These included maintenance men welders smiths and castings inspectors Of 29 X rayed, 9 had silicosis Stage 1 and all these had been exposed for 10 years and over Two of them had slight inactive tuberculosis

(6) *Sandblasters* Of 15 such men 2 had Stage 2 and 2 Stage 3 silicosis

(7) *Ingot mould men (Siemens furnaces)* No cases of silicosis were found amongst 9 examined

Wanek and Roosen (1944)(57) in a statistical study of the health records of 1 000 workers doing cold metal work 300 electric welders 250 autogenous welders and 675 foundry workers found that the annual disability through illness was highest amongst foundry workers and that they suffered from rheumatic affections more than the other groups Electric welders had a high morbidity rate from bronchial catarrh influenza and sore throat No mention is made of the pneumoconioses

Keatinge and Potter (1945)(58) carried out clinical X ray and environmental studies in two iron foundries in England employing over 700 workers They found that the fettling of medium and large castings was the dustiest occupation in the foundry Chemical analysis of the dust showed it to consist largely of silica particles In the foundries concerned it was estimated that the risk of silicosis to a fettler of large castings was 50 times greater than to a worker in the general body of the foundry medium fettling represented a 9 times greater risk and pneumatic mould filling and shaking out no more than 5 times Coreshop workers were exposed to a minimal risk Sickness and accident rates amongst the foundry workers were compared with those in a constructional department In the foundry group the number of cases of respiratory disease was lower than that in the constructional group though the average number of days lost per case was higher X ray examination of 60 men revealed no cases of silicosis but 21 per cent of them showed dust changes up to the stage of reticulation 40 per cent of the fettlers showed abnormal X ray changes Skin affections were more common in the foundry than in the constructional group dermatitis occurring most commonly amongst coremakers The incidence of rheumatic disease was also greater in the foundry than in the constructional department

Dunner Hermon and Bagnall (1945)(59) described the clinical and radiographic features of 13 radiator and boiler finishers (fettlers of iron castings) Eleven of them complained of cough and expectoration and 3 of shortness of breath In 2 the dyspnoea was so disabling that they were unable to continue at the job The characteristic X ray appearance consisted of fine bilateral mottling more marked in the middle and lower zones In one of the disabled men 56 years of age who had been an iron fettler for 45 years no abnormal X ray changes were seen and his condition appeared to be due to emphysema and premature senility Chemical analyses of the dust from the black sand coming off the castings showed that it contained total silica 65 8 per cent soluble silica 0 45 per cent iron 5 5 per cent and carbonaceous matter 15 1 per cent The authors concluded that these workers may develop pneumoconiosis and that though most of them feel fit for work in spite of the X ray changes disability may occur In Chapter V is an account of our histological studies of the lungs of an iron fettler who worked at this foundry

Eck (1946)(60) carried out an enquiry in France into the incidence of pneumoconiosis in industries other than mining and made an interesting attempt to

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melters, cranedrivers and sandmixers, 9 had silicosis Only 2 of 24 labourers showed signs of the disease The one sandblaster examined had a normal X-ray film

Merritt (1941)[54] who studied the silicosis claims allowed by the Ohio Indus-
1937 found that

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Eck (1946)[60] carried out an enquiry in France into the incidence of pneumoconiosis in industries other than mining and made an interesting attempt to

give to each occupation a figure or coefficient designed to show its comparative health risk For the steel and iron trades his results were as follows —

Foundries	*Results*	*Coeff. of risk*
Sandblasters	8 cases of silicosis out of 31 —	2 48
Castings Cleaners	1 „ „ „ „ „ 11 —	3 00
Chippers	12 „ „ „ „ „ 46 —	3 39
Moulders	2 „ „ „ „ „ 26 —	1 23
Grinders	3 „ „ „ „ „ 8 —	4 00
Various Operations	3 „ „ „ „ „ 28 —	1 75
Blast furnace masons	0 „ „ „ „ „ 7 —	0 85

sandblasters, fettlers and furnace bricklayers He concluded that the [illegible]

typical of pneumoconiosis caused by [illegible] was not substantiated Further, th[illegible] [illegible] advanced cases of pneumoconiosis, do not support [illegible] the fact that marked X-ray changes

[illegible] ent work on the effects of iron oxide dust on the lungs is relevant to health conditions in foundries Doig and McLaughlin (1936)([62]) found that electric arc welders, (and later also carbon arc and oxyacetylene welders) developed an X ray picture of the lungs which [illegible] other forms of pneumoconiosis and possibly miliary tuber-

[illegible] rie and [illegible] nfirmed [illegible] velders' [illegible] 941([69]), [illegible] l Lock- [illegible] hat the [illegible] ings of [illegible] n oxide

cribed 4 cases of what they called benign pneumoconiosis (siderosis) amongst 50 steel grinders Sander (1947[77]) recorded 3 cases in oxyacetylene cutters working in a foundry and Hamlin (1947[78] and 1948[79]) 4 cases in foundry grinders and burners In the last 3 series the men worked in rooms where there was also exposure to silica dust as well as iron but the amount of silica dust was considered too low to cause silicosis In Hamlin s cases there were shadows suggestive of superimposed infection but the progress of the lesions was incon sistent with the usual picture of tuberculosis associated with silicosis He con cluded that the X ray appearances were the result of the deposition of iron pigment (siderosis) rather than reaction in pulmonary tissue due to contact with free silica

Environmental Studies Studies of dust concentrations in foundries have been carried out by Middleton (1923)[23] in metal grinding and cleaning of castings Bloomfield and Greenburg (1933)[39] in sandblasting chambers and McConnell and Fehnel (1934)[35] in grey iron steel malleable iron and non ferrous foundries The results of a number of environmental studies in foundries are discussed in the annual reports of the Bureau of Occupational Diseases of the Connecticut State Department of Health (1933 1934 and 1936)[80] They found that dust concentrations in the general atmosphere of foundries varied from one foundry to another As much as 125 million particles per cubic foot were found in the general atmosphere of an iron foundry Thus high concentration was present soon after operations started in the morning In a brass foundry where good dust control measures had been instituted only 6 7 million particles per cubic foot were found in the general atmosphere Sand conditioning and shake out operations are amongst the dustiest processes in foundries and core making is the least dusty Moulding operations vary in dustiness from 2 to 80 million particles per cubic foot of air Abrasive blasting if the dust is uncontrolled constitutes the most severe health risk in the foundries dust concentrations of more than 1 000 million particles per cubic foot of air may be present inside sandblast rooms provided with average ventilation The dust concentrations in knock out tumbling barrel and grinding operations are also discussed but no mention is made of chipping or fettling of castings

A thorough investigation of the dust concentrations in Australian foundries was carried out by Ross and Shaw (1943)[8] to determine the dust exposure of employees in processes such as moulding shake out (or knock out as it is called in this country) sand conditioning abrasive blasting rumbling cleaning castings with wire brushes grinding chipping and annealing The results are given of the dust concentrations in 15 foundries (4 steel 6 grey iron 2 malleable iron and 3 ferrous and non ferrous) The actual dust concentrations are expressed in particle hours per c c a figure designed to represent the varying dustiness of foundry operations throughout the working shift In a discussion on per missible dust concentrations (a subject which has been given a good deal of attention by American investigators) they stated that despite a large volume of published work dealing both with the incidence of silicosis and other pulmonary fibroses in foundrymen and with the concentrations of dust to which they are exposed correlation of these two aspects to arrive at a safe limit of dustiness is not possible

It will be seen from the foregoing that intensive studies of the health of foundry workers have only been begun since 1931 and since then more than 25 radio graphic and/or clinical surveys of various groups have been made None of the investigations has included pathological studies It is difficult to make satisfactory comparisons between the results of these surveys because they vary not only in the numbers of workers examined but also in the types of foundries

In some investigations only workers following a specific foundry occupation

25 8 per cent that of 1st Stage silicosis ranges from 0 99 to 40 per cent, of 2nd and 3rd Stage silicosis from 0 1 to 64 per cent The incidence of silicosis com bined with tuberculosis varies from 0 25 to 12 per cent whereas that of active tuberculosis is between 0 6 and 32 per cent The high percentages invariably occur when only small numbers or when specialised groups exposed to high dust concentrations have been examined The studies however have been carried out in 13 different countries and there is at least unanimity in that silicosis and other types of pneumoconiosis have been found in foundry workers in all these countries

CHAPTER II

FOUNDRY PROCESSES

BY A I G McLAUGHLIN W B LAWRIE AND H WOODS

[illegible]

metal but in some of them iron steel and non ferrous metals are all handled The jobbing foundry is equipped to produce castings of varying shapes and weights but usually from one type of metal In the making of a casting there are certain fundamental processes First a pattern of the casting is made usually in wood but metal plaster special compounds or combinations of [illegible]

[illegible]

with its external surface conforming to the internal shape desired in the casting This core is then placed in the impression left in the mould by the pattern so that the molten metal fills the space between the core and the mould After the metal has solidified the sand is removed from the casting The initial rough removal of the sand is done by processes known as knocking out or stripping and the final cleaning by various processes is called dressing or fettling

Cores and moulds may be in green sand dry sand loam or oil sand Green sand is sand in its natural state and has about 4 per cent moisture Dry sand moulds are made from the same materials as green sand moulds but are dried before the metal is poured into them Small moulds are dried in ovens and large ones by mould driers or by coke fires and gas burners An intermediate type of mould is known as skin dried in which only the skin of a green sand mould is dried before the metal is run into the mould Loam moulds are always dried before casting takes place The use of sand mixed with oil is usually restricted to core making but the oil sand mould is now being developed These oil sand moulds and cores are baked in stoves The term baked is used in preference to dried because the process of baking involves chemical re actions in the binding agent and not merely the removal of moisture

[illegible]

further subdivided into (a) a sand preparation department where the ingredients for the moulding and core mixtures are prepared in the larger and mechanised

foundries a sand recovery plant may also be installed and (b) a moulding shop where the sand moulds are made either by hand or by machines In some instances all these operations are done in one large workroom The metal is also melted and cast in the foundry

(I) PATTERN SHOP

Patterns are made in a separate building placed at some distance from the other departments because it is necessary to keep the machinery and other equipment free from foundry dust The pattern makers work to designs prepared by

used Patterns in metal or in wood reinforced with metal are sometimes made and for this purpose a few metal working machines may be installed Compared with other foundry pr
deal of fine wood du
thrown up by the san
these machines to con
are apprenticed to it
their working lives
clear cut and uncomplicated

(II) FOUNDRY OR MOULDING SHOP

(a) *Moulding* The sand mixtures for moulds and cores are prepared

which gases and steam may escape The riser also acts as a
for the casting to draw on when it shrinks on cooling
on the foundry
facing'
near the
metal) consists of clay or chamotte which contains little or no free silica and that the use of such materials is being increased The backing of these moulds is still made with silica sand For treating mould surfaces mould

* In certain cases parting powder instead of sand is used Silica flour was most often used though non siliceous materials are now taking its place A bench moulder may make as many as 150 boxes in a shift and because the parting powder may be dusted twice on each box he may be enveloped during the shift in 300 dust clouds each having a high free silica content

paints and blacking such as graphite plumbago coal and other carbon dusts are used For green sand work the blacking is dusted on dry for dry sand moulds plumbago is made into a paste with clay water and a little gum This is painted on the mould surface

Moulding Materials Moulding sands have a h gh free silica (SiO_2) content as shown in the following table —

Sands	Light brass	78 80 per cent SiO
	Light cast iron	80 82 per cent SiO
	Medium cast iron	82 84 per cent SiO_2
	Heavy cast iron	84 – 88 per cent SiO_2
	Steel	90 – 95 per cent SiO_2

Sand used for mould making may be either naturally bonded or synthetic Naturally bonded moulding sands may occur in nature as mixtures of s lica sand and highly plastic clay (W J Rees 1944)([96]) Some of these sands are also

ture of two or more) or partly clay and partly organic (W J Rees) Proprietary core oils core creams and core compounds containing these constituents are often used Steel moulding composition or compo used for m k

cl

cr

prod cts of combustion of gas coal or coke burners In the better type of stove the products of combustion and other fumes are taken away by flues in others fumes escape from the stoves into the atmosphere of the foundry Fumes may

the fires are first lit during the baking process when the stove doors are not air tight and when the doors are open to load and unload the stoves Fumes also arise from the moulds and cores after casting has taken place

Portable mould driers consist of enclosed coke fires either blown directly by a fan or by air induced from a compressed air jet Less carbon monoxide is given off from coke driers than from open coke fires because in the former

foundries a sand recovery pla
where the sand moulds are r
instances all these operations
also melted and cast in the fo

(I)

Patterns are made in a s
other departments because i
ment free from foundry du
draughtsmen In a patter
working machines such as l
machines (Fig 2) in addi
used Patterns in metal o
and for this purpose a few
with other foundry proce
deal of fine wood dust
thrown up by the sandin
these machines to contro
are apprenticed to it at
their working lives O
clear cut and uncomplic

(II) FOUI

Two main operation
(a) the making of sand
metal In many founc
(a) *Moulding* The
by hand or in a speci
moulds on a bench if
when the castings are
consisting of upper
drag The cope is r
sand The pattern is t
on top of the cope f
over and the top onc
and parting powd
and the *moulding m*
can be taken out T
are usually treated v
Two channels are th
one through which
which gases and ste
for the casting to d
The same general
floor (Fig 3) or in p
material of moulds
metal) consists of c
that the use of su
moulds is still mac

* In certain cases p
used though non silice
many as 150 boxes in a
he may be enveloped d

least dusty of all foundry processes (except pattern making) because the e sand is intimately mixed with oil Cores are made either by hand or in a chine The composition of core sands has been discussed above

(IV) FETTLING SHOP (Figs 10 and 11)

Fettling is a general term which means cleaning and is used in this sense

car easily handled portable grinders (Fig 16) are used for a variety of purposes including the smoothing of internal surfaces of castings whereas swing frame grinders (Fig 13) are used on large castings

(f) *Brushing* In many iron foundries the castings are cleaned by holding

them against revolving wire brushes; in others again the castings are brushe by hand at a bench, sometimes under exhaust ventilation.

(g) *Hydroblast* A recent development in the cleaning of castings is t
water and sar
sting The sa
be used agai
for use by the moulders It is claimed that the hydroblast cleans the surface so that the necessity for dressing or fettling with pneumatic tools is eliminated The method is still in an experimental stage and it is too early to say wheth or not this claim is justified There is no doubt however that much of the dus usually created in the knock-out of the sand moulds and cores is controlled b this wet method

DUSTY PROCESSES

All foundry processes are dusty in varying degree, but the main dust producing operations are those connected with the removal of the moulds and

suppress the dust Another dusty operation which has not been previously

ing-out, stripping, rumbling, blasting, fettling and grinding
and rebuilding of furnace linings and ladles is also a dusty job.

FUMES AND GASES

Various fumes and gases may be given off into the air of foundries These are carbon monoxide, sulphur dioxide and a group of lachrymatory gases, probably resembling the aldehydes, e g acrolein Carbon monoxide comes

FIG 1 GENERAL VIEW OF A PATTERN SHOP

FIG 2 PATTERN SHOP—PATTERN MAKERS USING DISC SANDING MACHINES

FIG 3 GENERAL VIEW OF MOULDING SHOP—FLOOR MOULDING

[illegible] 4 [illegible] VIEW OF MOULDI[illegible]

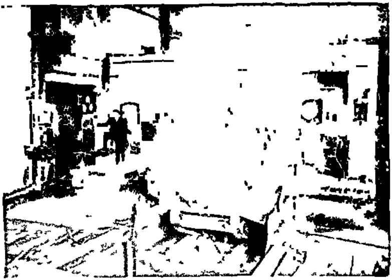

FIG 5 ELECTRIC ARC FURNACE

FIG 6 TAPPING AN ELECTRIC ARC FURNACE
MOLTEN METAL BEING RUN INTO A LADLE

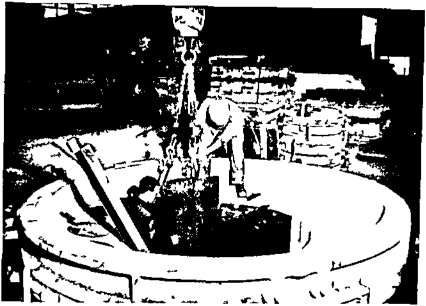

FIG 7 INSERTING CORES INTO A LARGE MOULD

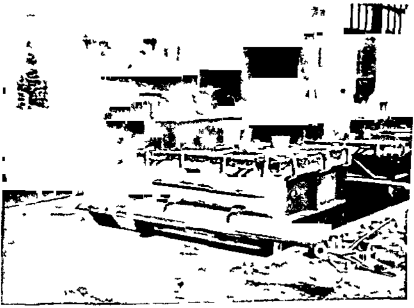

FIG 8 CASTING (POURING OR TEEMING) MOLTEN METAL INTO A LARGE MOULD

FIG 9 MOULDING SHOP—SHOWING LADLES AND PITS

FIG 10 STEEL FETTLING OR DRESSING SHOP ON THE LEFT THE MEN ARE USING PNEUMATIC TOOLS ON THE RIGHT SWING FRAME GRINDING MACHINES

FIG 11 VIEW OF ROUGH DRESSING SHOP—ON THE RIGHT A CASTING IS BEING "MUCKED OUT" ANNEALING FURNACES ON THE LEFT AND IN BACKGROUND

FIG 12 STRIPPING OR "MUCKING OUT" A LARGE STEEL CASTING

FIG 13 SWING FRAME GRINDING NOTE FLOOR GRID AND EXHAUST HOODS INTO WHICH SPARKS ARE FLYING

FIG 14 FLOOR STAND GRINDING (STEEL CASTING) NOTE EXHAUST VENTILATION SYSTEM

FIG 15. FETTLING INTERIOR OF LARGE INGOT MOULD. NOTE DUST CLOUD

FIG 16 FETTLING (FINISHING) A CLEAN CASTING WITH A PORTABLE GRINDING WHEEL

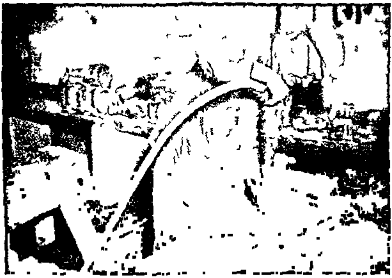

FIG 17 FETTLING (DRESSING OR FINISHING) A CLEAN CASTING WITH A PNEUMATIC CHISEL

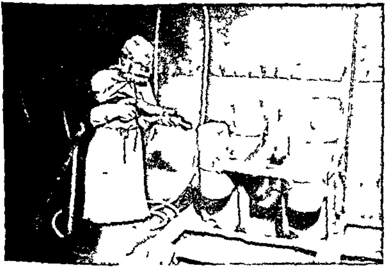

FIG 18 SHOTBLASTER INSIDE BLASTING CHAMBER THE BLAST IS NOT IN ACTION NOTE HELMET FITTED WITH FRESH AIR LINE

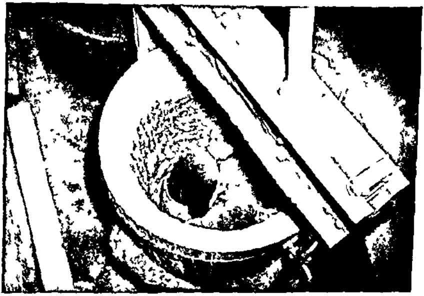

FIG 19 CHIPPING OUT THE LINING OF A LADLE
NOTE DUST CLOUD

CHAPTER III

METHODS OF INVESTIGATION

BY E A CHEESEMAN, H E. HARDING, JESSIE GARRAD AND A I G McLAUGHLIN

(i) X-RAY EXAMINATIONS

With the exception of 35 X-ray films of workers in foundry 'K'* all films were taken by Mr H T Ferrier and Mr J K. Maclagan of the British Red Cross Society. They used a mobile van which, carrying its own power, was independent of other sources of electricity In this way some 3,000 X-ray films of comparable technique were obtained and the radiography reached a high standard Details of the X-ray technique have been kindly supplied by Mr. Ferrier as follows —

"The Unit is mounted on a 27 h p Austin 4-ton chassis A 10 kilowatt generator, having an output of 515 volts at 100 cycles is mo[illegible] gear box and is operated by chain and sha[illegible] the special character[illegible] engine[illegible] with th[illegible] results, [illegible]

The X[illegible] designed [illegible]ecially to the alternator [illegible] up for this research work, is a four valve unit, at 90 kilovolts, operating a rotating anode tube with twin focal areas of one mm and 2 mm [illegible]

The technique on the site is as follows —

Distance 5 feet, approximately 68 k v, 250 m a, exposures range between 05 and 08, according to the thickness or density of the subject On occasions it has been possible to reduce the exposure to a twenty-fifth in very thin subjects It is possible to shorten the distance to 56 inches, having in mind the small focal area of the tube. The result, of course, is a great gain in speed with no loss of definition A stand, of our own design, permits rapid change of subject and cassette A large number of cassettes is in use, being "fed" to the operator by the assistant working in a dark room continually changing films It is possible, under these conditions, to average between 50 and 70 cases per hour according to the factory circumstances On occasions we have, where conditions have allowed, examined 90 cases an hour, but at this speed the work is too exhausting for continuous operation The car is completely equipped with all the usual accessories, a radiographic couch and a complete processing unit, thermostatically controlled from the generator on the car or the factory mains, so it is possible to develop and fix films on the spot when required "

The actual examinations were organised in such a way that about 100 X-ray films were taken in a day At some foundries the X-ray examinations were carried out after the clinical and other observations had been made but at others the work was so organised that both clinical and X-ray examinations were done on the same days

Interpretation of X-ray films All X-ray films were seen at least four times by three observers, M H Jupe, A I G McLaughlin, and K M A Perry. On the first occasion we studied the films in conjunction with the clinical records

* See code of factories, pages 23 and 24.

TABLE I NO OF MALES EMPLOYED BY BROAD OCCUPATIONAL GROUPS, IN EACH FACTORY AND THE NO USED IN THE SAMPLE OF X-RAY EXAMINATIONS

Factory	Moulding Shop Workers			Fettling Shop Workers			Other Workers			Total		
	Popl	Sample	%	Popl	Sample	%	Popl	Sample	%	Popl	Sample	%
A	212	141	67	71	57	80	129	63	49	412	261	63
B	89	80	90	13	12	92	66	20	30	168	112	67
C	147	117	80	16	16	100	111	23	21	272	156	57
D	58	42	72	8	7	88	15	12	80	81	61	75
	83	42	51	16	5	31	42	24	57	141	71	50
F	37	19	51	6	1	17	32	1	31	75	21	28
G	89	52	58	10	10	100	287	13	45	385	75	19
H	28	25	89	5	5	100	13	13	100	46	43	93
J	38	19	50	18	9	50	27	11	41	83	39	47
	34	31	91	1	1	100	—	—	—	35	32	91
	41	15	37	9	3	33	21	6	29	71	24	34
	145	112	77	92	85	92	44	26	59	281	223	79
	160	146	91	95	74	78	163	34	21	418	254	61
	498	186	37	305	185	61	422	190	45	1,225	561	46
R	215	180	84	96	88	92	145	106	74	454	374	82
S	317	255	80	125	98	78	103	75	73	545	428	79
T	52	25	48	22	7	32	27	—	—	101	32	32
	2,243	1,487	66	908	663	73	1,647	617	38	4,793	2,767	58

following groups —

Code of main group	Code of sub group	Occupations included
F		All workers in the moulding shop comprising —
	F1	Moulder including floor, sand, loam, bench, pit or machine moulder
	F2	Furnaceman including caster, ladleman, pourer, cupola man and annealer
	F3	Knock-out man, including stripper and mucker-out.
	F4	Sand mixer including sand recovery worker
	F5	Crane driver
	F6	Labourer including slinger, truck driver and internal dispatch man
	F7	Various occupations in the foundry
S		[illegible]
	S1	[illegible]
	S2	[illegible]
	S3	[illegible]
	S6	Labourer in fettling shop
	S7	Various occupations in fettling shop
O		All other [illegible]
	C	[illegible]
	P	[illegible]
	M	Administrative and maintenance staff, including [illegible]

(e) Factory at which workers were employed at the time of the investigation —

Code	Factory
A	Iron—East Midlands
B	Iron—South Eastern England
C	Iron—Midlands
D	Iron—South Eastern England
E	Iron—South Eastern England
F	Iron—East Midlands
G	Iron—East Midlands
H	Iron—South Eastern England

Code	*Factory*
J	Iron—South Eastern England
K	Iron—North Western England
L	Iron—South of England
M	Steel—North Eastern England
N	Steel—South of England
P	Steel—Midlands
R	Iron and steel—South Eastern England
S	Iron and steel—Midlands
T	Iron and steel—South of England

Sampling No attempt was made to sample the factory populations by a preconceived plan nor to take foundries in groups making various sizes of castings The sample obtained for each factory represents as many persons as could be persuaded to be examined There is little reason to suppose that the samples are biased, even so it is clear that comparisons between factories can *only be tentative and it should be recorded that at one factory at least (N)* periodical X-ray examinations have been carried out with a view to the transfer of suspected silicotic patients from the particular occupation in which they were engaged The size of the samples used for X ray classification compared with the total populations in the factories is shown in Table I In this table, the occupational grouping shown for the total factory populations represents a distribution of people in the occupations actually being followed at the time of the investigation on the other hand, the occupational distribution of the samples refers to occupation performed during past exposure, assessed as stated [illegible]

Statistical Treatment of X-ray Results

1 *Standardisation for age and length of exposure* If age and/or length of exposure influence X ray abnormality then any comparisons made between different groups drawn from the total population examined would be influenced by the age and length of exposure of the individuals in those groups Thus, in a group consisting largely of old men who have been exposed to industrial risks for long periods a higher incidence of X ray abnormalities might be expected than in a group of relatively young men exposed for only a short period [illegible] *could* [illegible] easily [illegible] therefc [illegible] betwee [illegible] length of exposure are probably closely related the removal of the effects of [illegible] ither one will remove the effects of the other *In fact a correlation of* $r = 0\ 6184$ with standard error 0 012 was found to exist between age and length of exposure of the total population *Though this shows a fairly high degree of* [illegible]

follows —

A table was prepared to show the distribution of the 2,767 workers by age, length of exposur[illegible] y classification, the time variables being grouped in

five-year periods Within each age and length of exposure "cell" of the table

X-ray Group I	62/74 - 0 837838
X-ray Group II	10/74 = 0 135135
X ray Group III	2/74 — 0 027027
X-ray Group IV	0/74 = 0 0

is for each X ray group —

X-ray Group I	20 × 0 837838 =	16 76
X ray Group II	20 × 0 135135 =	2 70
X-ray Group III	20 × 0 027027 —	0 54
X ray Group IV	20 × 0 0	0

The difference between the "expected" number of subjects in any one X-ray category in a sample and the observed number indicates the divergence from the aggregate after having taken the differing age and length of exposure constitutions into account To facilitate comparisons between samples the percentage ratio "observed/expected" has been used, thus, if in a group of individuals, say A, the ratio for X-ray Group II is 110, then Group A contains more individuals classified as X ray Group II than we should expect from the aggregate experience, if in another Group B the corresponding ratio is 90 the converse is true and finally a direct comparison between the ratio 110 for Group A and 90 for Group B can be made and it follows that Group B has a lower incidence rate of this X ray category than Group A, age and length of exposure

... error of it is given by $\sqrt{\Sigma nq(1-q)}$ where q is the probabilit... being assigned in each specific age and length of exposu...

The standard error of E can be assumed to be zero since it is based on the total population and the standard error of the ratio

$$\frac{R \times 100}{E} \text{ thus becomes } \frac{100\sqrt{E}}{E} \text{ or } \frac{100}{\sqrt{E}}$$

For the purposes of examining the ratios calculated below it has been assumed that q is small for X ray Groups II, III and IV (but such an assumption *is not justified for X ray Group I) It is considered that no great error will be* involved since the tests applied involve a greater stringency in the assessment for significance when the approximate form above is used than would be incurred with the exact expression of the standard error of the ratio

r than twice

differ from

n implies an

observation in the sample which differs significantly from the aggregate Similarly the significance of the difference between any two samples can be assessed in terms of the standard error of that difference $\sqrt{(S\,E_1)^2 + (S\,E_2)^2}$ *where* $S\,E_1$ *is the standard error of the ratio in the first sample and* $S\,E_2$ *is* that of the second

3 *Statistical Treatment of Clinical Data* Similar statistical methods were applied to the numbers of cases giving a previous history of pneumonia or pleurisy and to the results of exercise tolerance tests The data relating to vital capacity, a quantitative variable required special treatment and further reference to this is given below (see page 65)

(v) PATHOLOGICAL INVESTIGATIONS

Over a period of 10 years the lungs of 64 foundry workers have been studied by Dr S Roodhouse Gloyne Pathologist to the London Chest Hospital and

The cases

e Factory

al Board

d for each

dy o the

into a platinum crucible, and

oven When cool, the weight of

determ ned

hed for

representation of the amounts of free silica present All results by this method are checked by treating the residue with hydrofluoric acid, and are rejected as unreliable if more than a trace is left after such treatment

(vi) ENVIRONMENTAL

It should be recorded that the environmental studies planned as part of the general investigation have not proceeded satisfactorily It had been hoped to include in this report complete studies for each factory but owing to such circumstances as change of staff, loss of dust samples during a move to new laboratories and pressure of other work no complete environmental study of any of the factories on our list has yet been done

In the case of one factory (M) dust samples were taken by one of us (A I G McL) with the Owen s Dust Counter and the results of this investigation will be given to show the type of dust concentrations encountered in a steel moulding shop and a fettling shop

these will be made No clinical or X ray examinations were made at the steel foundry The methods of investigation will be described in Mr Goodall's chapters

CHAPTER IV

RESULTS OF INVESTIGATION

BY E A CHEESEMAN, JESSIE GARRAD, M H JUPE, A I G. McLAUGHLIN, AND K M A PERRY

(1) CLASSIFICATION OF X-RAY APPEARANCES

Before dealing with the results of the examinations it is necessary to discuss

field investigation amongst anthracite miners was not entirely applicable. These inves
changes in
lation, nod
fluffy shado
categories
dusty industries tend in each industry to develop patterns which may be fairly characteristic for the industry After study of some hundreds of foundry workers' chest films we came to the conclusion that a modified classification was also necessary for our purposes

Increased linear striation The classification adopted by Hart and Aslett does not take into account the change usually called "increased linear

line exists between what can be called normal linear markings and the stage of increased linear striation It is considered by many observers that the linear
blood vessels
port this
vn clearly

d vessels and bronchi

eased linear striation
While we regard this change as
ormal (that is, a man showing this appearance in his X-ray film will probably have no abnormal signs

Reticulation Hart and Aslett used the term "reticulation" which can be

dust in the lymph channels and depots It has not yet been shown that the

1948[73]) have shown that X ray films of the chests of such workers show abnormal shadows which have a reticular and sometimes nodular pattern, and on histological examination the lungs show no increase in reticular or collagenous tissue in relation to the deposits of iron oxide dust These abnormal appearances are caused simply by the fact that iron oxide or any metallic dust is opaque to X rays, the density of the opacities varying directly with the atomic weight of the metal It is important to note that on radiographic evidence alone it may be impossible to determine whether an appearance of reticulation is due to early silicosis, miliary tuberculosis or other pathological conditions or to

combustion of the fuel used to heat them Near the sand mixing operations

there ma be fine d st of s nd nd l M d r d

1

addition there is an admixture of iron scale from the surface of the castings If welding or oxyacetylene burning is carried on in the shops iron oxide is present in the fume which arises from the weld and is inhaled in great quant t es by the welders or oxyacetylene burners and in a lesser amount by workers in their vicinity Any classification of X ray changes in foundry workers must therefore take into account the abnormal changes likely to be set up in the lungs by two main types of dust (1) the dust of free silica which will cause

then be made on clinical evidence

Nodulation Pendergrass([88]) defines nodulation as discrete shadows not exceeding 6 mm in diameter tending to uniformity of size density and bilateral distribution with well defined borders surrounded by apparently normal lung

reticulation or nodulation depending on the predominance of the one or the other For certain purposes we have used the category of reticulo nodulation

Conglomerate or massive shadows We prefer this term to Hart and Aslett s

is rare in foundry workers

For our X ray categories we have adopted the following list for clinical pi rposes —

1 Normal (including increased linear striation and/or stippling and ground glass appearance)
2 Early or suspected reticulation
3 Reticulation
4 Nodulation
5 Massive Shadows
6 Tuberculosis

For stat stical purposes we have adopted a shorter list as follows —

Category I = Normal
II = Early Reticulation
III — Reticulation
IV — Nodulation and/or Massive Shadows

The shorter classif cation w is adopted because of the small numbers occurring in some of the groups

foundry workers was e given here for com the scheme adopted with an investigation follows — 1 of normal pulmonic

markings

B Second degree exaggeration of normal pulmonic markings

C First degree diffuse ground glass appearance not obliterating linear markings, presenting fine discrete nodules stereoscopically and pathologically.

D [illegible]

E. [illegible]

F. [illegible]

usually present

[illegible]

stages

Clinical	*Statistical*	*Brown and Klein*
1	I	A, B and possibly C.
2	II	C and possibly D
3	III	D and possibly E.
4, 5	IV	E, F and G.

With these considerations in mind we can now proceed to discuss the results of the X-ray examinations

TABLE II DISTRIBUTION OF WORKERS BY TYPE OF EXPOSURE AND X-RAY CATEGORY

Males — All Factories combined

Type of exposure	X ray Group I	II	III	IV	TOTAL
IRON	691	160	51	9	911
STEEL	696	215	176	33	1,120
MIXED	587	100	45	4	736
TOTAL	1 974	475	272	46	2 767
Number of workers in each group as percentage of total					
IRON	76	18	6	1	101
STEEL	62	19	16	3	100
MIXED	80	14	6	1	101
TOTAL	71	17	10	2	100

(ii) RESULTS OF X-RAY EXAMINATIONS

[STATISTICAL ANALYSIS]

The 2,767 male foundry workers were divided into 3 groups according to their exposure in iron, steel or mixed iron and steel foundries The results of the X ray examinations are given in Table II Each X ray film was examined independently by 3 observers and for statistical purposes put into one of the 4 categories defined above (see page 30)

All occupations combined Of 2 767 workers 1,974 (71 per cent) showed no abnormal X ray changes 475 (17 per cent) had early reticulation 272 (10 per cent) showed reticulation and 46 (2 per cent) had nodulation (with or without [illegible]) [illegible] the figures for the 3 categories of exposure iron,

[illegible]

and steel workers The difference is [illegible]
chance
allowance
groups
all 3 types of workers the percentages being 18 for iron 19 for steel and 14 for mixed iron and steel As a corollary the percentage of normal films is lower amongst steel workers than in the other two groups, (76 iron 62 steel and 80 mixed)

[illegible]

[illegible] as the samples [illegible] and (b) the pro- [illegible] samples do not [illegible] from which such samples are drawn and as is shown later [illegible] does affect the *X ray distributions*

TABLE XVI DISTRIBUTION OF IRON EXPOSED SUBJECTS BY X RAY CATEGORY, AGE LENGTH

Males — All factories

Age in years	X ray group	0 No	0 %	5 No	5 %	10– No	10– %	20– No	20– %	30+ No	30+ %	Total No	Total %
10	I	94	90	43	91	37	79	1	100	—		175	89
	II	10	9	4	9	3	6	—		—		17	9
	III & IV	1	1	—		7	15			—		8	4
	Total	105	100	47	100	47	100	1	100	—		200	101
30	I	28	76	42	89	82	72	36	62	—		188	73
	II	9	24	4	9	19	17	19	33	—		51	20
	III & IV	—		1	2	13	11	3	5	—		17	7
	Total	37	100	47	100	114	100	58	100	—		256	100
40–	I	19	90	24	83	24	67	78	80	13	72	158	7[illegible]
	II	2	10	4	14	10	28	16	16	5	28	37	1[illegible]
	III & IV	—		1	3	2	6	4	4	—		7	[illegible]
	Total	21	100	29	100	36	101	98	100	18	100	202	100
50+	I	18	82	14	78	15	83	37	71	86	60	170	67
	II	3	14	3	17	1	6	13	25	35	24	55	22
	III & IV	1	5	1	5	2	11	2	4	22	16	28	11
	Total	22	101	18	100	18	100	52	100	143	100	253	100
Total	I	159	86	123	87	158	73	152	73	99	61	691	76
	II	24	13	15	11	33	15	48	23	40	25	160	18
	III & IV	2	1	3	2	24	11	9	4	22	14	60	6
	Total	185	100	141	100	215	100	209	100	161	100	911	100

Figures in italics represent percentage distributions in each cell

TABLE XVII DISTRIBUTION OF STEEL EXPOSED SUBJECTS BY X RAY CATEGORY, AGE, LENGTH

Males — All factories

Age in years	X ray group	Length of exposure in years											
		0—		5—		10—		20—		30+		Total	
		No	%	No	%	No	%	No	%	No	%	No	%
10—	I	148	*96*	77	*85*	28	*67*	—		—		253	*88*
	II	5	*3*	10	*11*	7	*17*	—		—		22	*8*
	III & IV	1	*1*	4	*4*	7	*17*	—		—		12	*4*
	Total	154	*100*	91	*100*	42	*101*	—		—		287	*100*
30—	I	53	*79*	63	*64*	63	*54*	25	*45*	—		204	*60*
	II	11	*16*	20	*20*	30	*26*	18	*32*	—		79	*23*
	III & IV	3	*4*	15	*15*	24	*21*	13	*23*	—		55	*16*
	Total	67	*99*	98	*99*	117	*101*	56	*100*	—		338	*99*
40—	I	37	*74*	44	*60*	21	*46*	39	*35*	2	*17*	143	*49*
	II	11	*22*	15	*21*	9	*20*	27	*24*	4	*33*	66	*23*
	III & IV	2	*4*	14	*19*	16	*35*	46	*41*	6	*50*	84	*29*
	Total	50	*100*	73	*100*	46	*101*	112	*100*	12	*100*	293	*101*
50+	I	26	*70*	21	*55*	10	*56*	22	*51*	17	*26*	96	*48*
	II	8	*22*	9	*24*	3	*17*	7	*16*	21	*32*	48	*24*
	III & IV	3	*8*	8	*21*	5	*28*	14	*33*	28	*42*	58	*29*
	Total	37	*100*	38	*100*	18	*101*	43	*100*	66	*100*	202	*101*
Total	I	264	*86*	205	*68*	122	*55*	86	*41*	19	*24*	696	*62*
	II	35	*11*	54	*18*	49	*22*	52	*25*	25	*32*	215	*19*
	III & IV	9	*3*	41	*14*	52	*23*	73	*35*	34	*44*	209	*19*
	Total	308	*100*	300	*100*	223	*100*	211	*101*	78	*100*	1120	*100*

Figures in italics represent percentage distributions in each cell

TABLE XVIII DISTRIBUTION OF 'MIXED' EXPOSED SUBJECTS BY X RAY CATEGORY, AGE, LENGTH

Males — All factories

Age in years	X ray group	0— No	0— %	5— No	5— %	10— No	10— %	20— No	20— %	30+ No	30+ %	Total No	Total %
		Length of exposure in years											
10—	I	56	*95*	32	*91*	29	*94*	—		—		117	*94*
	II	2	*3*	3	*9*	2	*6*	—		—		7	*6*
	III & IV	1	*2*	—	—	—	—	—		—		1	*1*
	Total	59	*100*	35	*100*	31	*100*	—		—		125	*101*
30—	I	61	*98*	26	*81*	95	*82*	35	*83*	—		217	*86*
	II	1	*2*	5	*16*	15	*13*	6	*14*	—		27	*11*
	III & IV	—	—	1	*3*	6	*5*	1	*2*	—		8	*3*
	Total	62	*100*	32	*100*	116	*100*	42	*99*	—		252	*100*
40—	I	34	*92*	17	*77*	34	*76*	40	*61*	19	*79*	144	*74*
	II	3	*8*	4	*18*	8	*18*	16	*24*	2	*8*	33	*17*
	III & IV	—	—	1	*5*	3	*7*	10	*15*	3	*13*	17	*9*
	Total	37	*100*	22	*100*	45	*101*	66	*100*	24	*100*	194	*100*
50+	I	9	*82*	8	*73*	6	*67*	20	*65*	66	*64*	109	*66*
	II	2	*18*	2	*18*	2	*22*	7	*23*	20	*19*	33	*20*
	III & IV	—	—	1	*9*	1	*11*	4	*13*	17	*17*	23	*14*
	Total	11	*100*	11	*100*	9	*100*	31	*101*	103	*100*	165	*100*
Total	I	160	*95*	83	*83*	164	*82*	95	*68*	85	*67*	587	*80*
	II	8	*5*	14	*14*	27	*13*	29	*21*	22	*17*	100	*13*
	III & IV	1	*1*	3	*3*	10	*5*	15	*11*	20	*16*	49	*7*
	Total	169	*101*	100	*100*	201	*100*	139	*100*	127	*100*	736	*100*

Figures in italics represent percentage distribution in each cell

TABLE XIX DISTRIBUTION OF IRON MOULDING SHOP WORKERS BY X RAY CATEGORY AGE LENGTH

Males

Age in years	X ray group	*Length of exposure in years* 0—		5—		10—		20—		30+		Total	
		No	%	No	%	No	%	No	%	No	%	No	
10—	I	42	*81*	31	*91*	30	*77*	1	*100*	—	—	104	*83*
	II	9	*17*	3	*9*	3	*8*	—	—	—	—	15	*1*
	III & IV	1	*2*	—	—	6	*15*	—	—	—	—	7	*6*
	Total	52	*100*	34	*100*	39	*100*	1	*100*	—	—	126	*101*
30—	I	23	*77*	32	*91*	56	*71*	25	*64*	—	—	136	*74*
	II	7	*23*	3	*9*	12	*15*	13	*33*	—	—	35	*19*
	III & IV		—	—	—	11	*14*	1	*3*	—	—	12	*7*
	Total	30	*100*	35	*100*	79	*100*	39	*100*	—	—	183	*100*
40	I	11	*85*	13	*76*	16	*73*	51	*82*	9	*69*	100	*79*
	II	2	*15*	3	*18*	4	*18*	10	*16*	4	*31*	23	*18*
	III & IV	—	—	1	*6*	2	*9*	1	*2*	—	—	4	*3*
	Total	13	*100*	17	*100*	22	*100*	62	*100*	13	*100*	127	*100*
50	I	11	*92*	8	*73*	9	*82*	24	*73*	63	*60*	115	*66*
	II	1	*8*	2	*18*	2	*18*	8	*24*	28	*27*	39	*23*
	III & IV		—	1	*9*	—	—	1	*3*	15	*14*	19	*11*
	Total	12	*100*	11	*100*	11	*100*	33	*100*	106	*101*	173	*100*
Total	I	87	*81*	84	*87*	111	*74*	101	*75*	72	*61*	455	*75*
	II	19	*18*	11	*11*	21	*14*	31	*23*	32	*27*	112	*18*
	III & IV	1	*1*	2	*2*	19	*13*	3	*2*	15	*13*	42	*7*
	Total	107	*100*	97	*100*	151	*101*	135	*100*	119	*101*	609	*100*

Figures in italics represent percentage distribution in each cell

TABLE XX DISTRIBUTION OF STEEL MOULDING SHOP WORKERS BY X RAY CATEGORY AGE LENGTH

Age in years	X ray group	Males											
		Length of exposure in years											
		0–		5–		10–		20–		30		Total	
		No	%	No	%	No	%	No	%	No	%	No	%
10–	I	54	*96*	42	*95*	7	*70*	—	—	—	—	103	*94*
	II	2	*4*	2	*5*	3	*30*	—	—	—	—	7	*6*
	III & IV	—	—	—	—	—	—	—	—	—	—	—	—
	Total	56	*100*	44	*100*	10	*100*	—	—	—	—	110	*100*
30	I	19	*90*	29	*67*	38	*68*	19	*49*	—	—	105	*66*
	II	1	*5*	8	*19*	14	*25*	15	*38*	—	—	38	*24*
	III & IV	1	*5*	6	*14*	4	*7*	5	*13*	—	—	16	*10*
	Total	21	*100*	43	*100*	56	*100*	39	*100*	—	—	159	*100*
40–	I	11	*79*	24	*71*	10	*56*	26	*41*	—	—	71	*53*
	II	3	*21*	5	*15*	6	*33*	19	*30*	4	*67*	37	*27*
	III & IV	—	—	5	*15*	2	*11*	18	*29*	2	*33*	27	*20*
	Total	14	*100*	34	*101*	18	*100*	63	*100*	6	*100*	135	*100*
50	I	9	*82*	11	*56*	8	*50*	11	*65*	7	*21*	46	*47*
	II	2	*18*	6	*30*	3	*19*	5	*29*	12	*36*	28	*29*
	III & IV	—	—	3	*14*	5	*31*	1	*6*	14	*42*	23	*24*
	Total	11	*100*	20	*100*	16	*100*	17	*100*	33	*99*	97	*100*
Total	I	93	*91*	106	*75*	63	*63*	56	*47*	7	*18*	325	*65*
	II	8	*8*	21	*15*	26	*26*	39	*33*	16	*41*	110	*22*
	III & IV	1	*1*	14	*10*	11	*11*	24	*20*	16	*41*	66	*13*
	Total	102	*100*	141	*100*	100	*100*	119	*100*	39	*100*	501	*100*

Figures in italics represent percentage distribution in each cell

XXI DISTRIBUTION OF MIXED MOULDING SHOP WORKERS BY X RA' CATEGORY, AGE, LENGTH

Males

X ray group	Length of exposure in years											
	0—		5 —		10—		20—		30 +		Total	
	No	%	No	%	No	%	No	%	No	%	No	%
I	25	*93*	10	*91*	13	*87*	—	—	—	—	48	*91*
II	1	*4*	1	*9*	2	*13*	—	—	—	—	4	*8*
III & IV	1	*4*	—	—	—	—	—	—	—	—	1	2
Total	27	*101*	11	*100*	15	*100*	—	—	—	—	53	*101*
I	30	*100*	8	*80*	56	*85*	14	*100*	—	—	108	*90*
II	—	—	2	*20*	6	*9*	—	—	—	—	8	*7*
III & IV	—	—	—	—	4	*6*	—	—	—	—	4	*3*
Total	30	*100*	10	*100*	66	*100*	14	*100*	—	—	120	*100*
I	22	*96*	11	*79*	16	*67*	18	*55*	10	*72*	77	*7'*
II	1	*4*	2	*14*	5	*21*	9	*27*	2	*14*	19	*18*
III & IV	—	—	1	*7*	3	*13*	6	*18*	2	*14*	12	*11*
Total	23	*100*	14	*100*	24	*101*	33	*100*	14	*100*	108	*101*
I	7	*88*	4	*80*	4	*80*	9	*60*	40	*63*	64	*67*
II	1	*12*	1	*20*	1	*20*	3	*20*	13	*21*	19	*20*
III & IV	—	—	—	—	—	—	3	*20*	10	*16*	13	*14*
Total	8	*100*	5	*100*	5	*100*	15	*100*	63	*100*	96	*101*
I	84	*96*	33	*83*	89	*81*	41	*66*	50	*65*	297	*79*
II	3	*3*	6	*15*	14	*13*	12	*19*	15	*19*	50	*13*
III & IV	1	*1*	1	2	7	*6*	9	*15*	12	*16*	30	*8*
Total	88	*100*	40	*100*	110	*100*	62	*100*	77	*100*	377	*100*

Figures in italics represent percentage distribution in each cell

TABLE XXII DISTRIBUTION OF IRON FETTLING SHOP WORKERS BY X RAY CATEGORY, AGE, LENGTH

Males

Age in years	X ray group	Length of exposure in years 0 No	%	5— No	%	10— No	%	20— No	%	30+ No	%	Total No	%
10—	I	11	*100*	4	*80*	3	*75*	—	—	—	—	18	*90*
	II	—	—	1	*20*	—	—	—	—	—	—	1	*5*
	III & IV	—	—	—	—	1	*25*	—	—	—	—	1	*5*
	Total	11	*100*	5	*100*	4	*100*	—	—	—	—	20	*100*
30—	I	5	*71*	6	*75*	7	*47*	4	*40*	—	—	22	*55*
	II	2	*29*	1	*13*	6	*40*	5	*50*	—	—	14	*35*
	III & IV	—	—	1	*13*	2	*13*	1	*10*	—	—	4	*10*
	Total	7	*100*	8	*101*	15	*100*	10	*100*	—	—	40	*100*
40—	I	7	*100*	9	*90*	8	*62*	13	*68*	—	—	37	*76*
	II	—	—	1	*10*	5	*38*	3	*16*	—	—	9	*18*
	III & IV	—	—	—	—	—	—	3	*16*	—	—	3	*6*
	Total	7	*100*	10	*100*	13	*100*	19	*100*	—	—	49	*100*
50+	I	2	*40*	3	*75*	3	*75*	3	*38*	3	*23*	14	*41*
	II	2	*40*	1	*25*	1	*25*	4	*50*	3	*23*	11	*32*
	III & IV	1	*20*	—	—	—	—	1	12	7	*54*	9	*27*
	Total	5	*100*	4	*100*	4	*100*	8	*100*	13	*100*	34	*100*
Total	I	25	*83*	22	*81*	21	*58*	20	*54*	3	*23*	91	*64*
	II	4	*14*	4	*15*	12	*33*	12	*32*	3	*23*	35	*24*
	III & IV	1	*3*	1	*4*	3	*8*	5	*14*	7	54	17	*12*
	Total	30	*100*	27	100	36	*99*	37	*100*	13	*100*	143	*100*

Figures in italics represent percentage distribution in each cell

TABLE XXIII DISTRIBUTION OF STEEL FETTLING SHOP WORKERS BY X RAY CATEGORY, AGE, LENGTH

Males

Age in years	*X ray group*	Length of exposure in years											
		0—		5—		10—		20—		30+		Total	
		No	%	No	%	No	%	No	%	No	%	No	%
10—	I	37	*93*	18	*62*	11	*55*	—	—	—	—	66	*74*
	II	2	*5*	7	*24*	3	*15*	—	—	—	—	12	*13*
	III & IV	1	*3*	4	*14*	6	*30*	—	—	—	—	11	*12*
	Total	40	*101*	29	*100*	20	*100*	—	—	—	—	89	*99*
30—	I	21	*68*	26	*55*	10	*24*	2	*17*	—	—	59	*45*
	II	8	*26*	12	*26*	12	*29*	2	*17*	—	—	34	*26*
	III & IV	2	*6*	9	*19*	19	*46*	8	*67*	—	—	38	*29*
	Total	31	*100*	47	*100*	41	*99*	12	*101*	—	—	131	*100*
40—	I	18	*72*	14	*50*	4	*20*	4	*11*	1	*20*	41	*36*
	II	6	*24*	7	*25*	2	*10*	4	*11*	—	—	19	*17*
	III & IV	1	*4*	7	*25*	14	*70*	28	*78*	4	*80*	54	*47*
	Total	*25*	*100*	*28*	*100*	*20*	*100*	*36*	*100*	*5*	*100*	*114*	*100*
50	I	8	*57*	5	*50*	—	—	5	*29*	2	*8*	20	*31*
	II	4	*29*	1	*10*	—	—	—	—	8	*35*	13	*20*
	III & IV	2	*14*	4	*40*	—	—	12	*71*	13	*57*	31	*48*
	Total	14	*100*	10	*100*	—	—	17	*100*	23	*100*	64	*99*
Total	I	84	*76*	63	*55*	25	*31*	11	*17*	3	*11*	186	*47*
	II	20	*18*	27	*24*	17	*21*	6	*9*	8	*29*	78	*20*
	III & IV	6	*6*	24	*21*	39	*48*	48	*74*	17	*61*	134	*34*
	Total	110	*100*	114	*100*	81	*100*	65	*100*	28	*101*	398	*101*

Figures in italics represent percentage distributions in each cell

TABLE XXIV DISTRIBUTION OF MIXED FETTLING SHOP WORKERS BY X RAY CATEGORY, AGE, LENGTH

Age in years	X ray group	Length of exposure											
		0—		5—		10—		20—		30+		Total	
		No	%	No	%	No	%	No	%	No	%	No	%
10—	I	6	*86*	1	*33*	4	*100*	—	—	—	—	11	*79*
	II	1	*14*	2	*67*	—	—	—	—	—	—	3	*21*
	III & IV	—	—	—	—	—	—	—	—	—	—	—	—
	Total	7	*100*	3	*100*	4	*100*	—	—	—	—	14	*100*
30—	I	12	*100*	10	*71*	12	*60*	5	*56*	—	—	39	*71*
	II	—	—	3	*22*	6	*30*	3	*33*	—	—	12	*22*
	III & IV	—	—	1	*7*	2	*10*	1	*11*	—	—	4	*7*
	Total	12	*100*	14	*100*	20	*100*	9	*100*	—	—	55	*100*
40—	I	4	*67*	1	*50*	7	*70*	4	*33*	1	*50*	17	*53*
	II	2	*33*	1	*50*	3	*30*	4	*33*	—	—	10	*31*
	III & IV	—	—	—	—	—	—	4	*33*	1	*50*	5	*16*
	Total	6	*100*	2	*100*	10	*100*	12	*99*	2	*100*	32	*100*
50+	I	1	*100*	1	*50*	1	*100*	1	*17*	6	*55*	9	*43*
	II	—	—	—	—	—	—	4	*67*	—	—	5	*24*
	III & IV	—	—	1	*50*	—	—	1	*17*	5	*45*	7	*33*
	Total	1	*100*	2	*100*	1	*100*	6	*101*	11	*100*	21	*100*
Total	I	23	*88*	13	*62*	24	*69*	10	*37*	7	*54*	76	*62*
	II	3	*12*	6	*29*	9	*26*	11	*41*	—	—	30	*25*
	III & IV	—	—	2	*10*	2	*6*	6	*22*	6	46	16	*13*
	Total	26	*100*	21	*101*	35	*101*	27	*100*	13	*100*	122	*100*

Figures in italics represent percentage distributions in each cell

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trend ... those which appear with a reasonable degree of consistency.

For all ages combined it will be seen that in each type of exposure the incidence of abnormality increases with increasing length of exposure. This is particularly noticeable amongst steel workers who, moreover, show an incidence rate higher than either the iron or the "mixed" group at each length of exposure As far as can be seen these features of the experience appear or are suggested quite strongly in most of the age groups studied

If the incidence ...

age groups appears to flatten at later ages

If the data are split in such a way as to show similar information for moulding shop workers and fettling shop workers separately, though such groups are still not representative of their fellows in the total population, the occupational bias of the preceding tables XVI, XVII and XVIII, is to some extent overcome. This information is shown in Tables XIX, XX and XXI, for moulding shop workers and XXII, XXIII and XXIV, for fettling shop workers for the iron and steel and "mixed" groups respectively It is possible only to generalise from these tables since trends are possibly obscured by the smallness of the numbers in some groups but it does appear that the experience of the moulding shop workers follows very closely both the level and the trends of the total

occupations combined" and the moulding shop workers group, though generally the trend of such incidence follows the other occupational groups.

Comparison of broad occupational groups of Foundry Workers, by occupation ... 3 broad ... ups are ... al sub- ... Table

is given in the text.

continuing the discussion in terms of the crude figures

TABLE III DISTRIBUTION OF WORKERS BY TYPE OF EXPOSURE, X RAY CATEGORY AND OCCUPATION (BROAD GROUPS)

Males | All factories

Occupation group	Type of exposure	No of workers: X ray Groups I	II	III & IV	Total	As percentage of all X ray groups: X ray Groups I	II	III & IV	Total
Moulding shop workers	IRON	455	112	42	609	75	18	7	100
	STEEL	325	110	66	501	65	22	13	100
	MIXED	297	50	30	377	79	13	8	100
Fettling shop workers	IRON	91	35	17	143	64	24	12	100
	STEEL	186	78	134	398	47	19	34	100
	MIXED	76	30	16	122	62	25	13	100
Other workers	IRON	145	13	1	159	91	8	1	100
	STEEL	185	27	9	221	84	12	4	100
	MIXED	214	20	3	237	90	9	1	100

N OF MOULDING SHOP WORKERS BY TYPE OF EXPOSURE, X-RAY CATEGORY, OCCUPATIONAL SUB-GROUPS

All factories

	Type of Exposure	No of workers: X ray groups I	II	III & IV	Total	As percentage of all X-ray Groups: X ray groups I	II	III & IV	Total
	IRON	246	68	30	344	72	20	9	101
	STEEL	146	55	23	224	65	25	10	100
	MIXED	109	24	16	149	73	16	11	100
	IRON	20	9	1	30	67	30	3	100
	STEEL	37	15	14	66	56	23	21	100
	MIXED	23	5	—	28	82	18	—	100
	IRON	32	4	1	37	87	11	3	101
	STEEL	39	21	10	70	56	30	14	100
	MIXED	20	—	—	20	100	—	—	100
	IRON	72	17	3	92	78	19	3	100
	STEEL	71	11	9	91	78	12	10	100
	MIXED	58	4	1	63	92	6	2	100
	IRON	85	14	7	106	80	13	7	100
	STEEL	32	8	10	50	64	16	20	100
	MIXED	87	17	13	117	74	15	11	100

employed in this group are somewhat higher than in the previous group In both iron and steel foundries 78 per cent had normal chest films, but the inci-

be seen that there were 92 per cent with normal films, 6 per cent with early reticulation and 2 per cent with reticulation

(v) *Various Occupations in the Moulding Shop* This group includes those men who had done so many types of jobs in the moulding shop that they could not be put into any definite group Again the steel workers show a higher incidence of X ray abnormalities, only 64 per cent having normal chest films as

Table V shows the observed/expected ratios for moulding shop workers Between exposure types for all moulding shop workers combined a difference was found to exist in the distribution of X ray classifications Examination of

ratios, is significant —

(i) Furnace workers steel ratio exceeds mixed ratio by 159 ± 65 and
(ii) Various occupations' steel ratio exceeds iron ratio by 112 ± 47

This might be expressed thus — From these data it appears that furnace workers in steel foundries show a greater incidence of X ray reticulation and nodulation than do furnace workers in mixed foundries, age and length of exposure being taken into account Similarly, workers in the various occupations group in steel foundries show more such abnormalities than the comparable group in iron foundries These differences are unlikely to have arisen by chance

The incidence of mild X ray abnormality results in a higher ratio in the steel group than in the others amongst moulders and knock out men etc, the differences in each case being statistically significant —

	Steel – Iron	*Steel mixed'*
Moulders etc	42 ± 21	67 ± 25
Knock out men etc	(98 ± 49)	(160 ± 67)

Amongst the 'various occupations results consistent with this, but not technically significant, are apparent but the position is somewhat uncertain with regard to X-ray group II for furnace workers and the experience of moulding shop labourers is at variance with the general results for the foundry For labourers the ratio observed for the steel group is the minimum and in fact is significantly less than the "mixed' group ratio (The difference is 110 ± 42)

If a comparison is made between the ratios observed for the various occupations, for each type of exposure held constant, no significantly great differences

TABLE VI. DISTRIBUTION OF FETTLING SHOP WORKERS BY TYPE OF EXPOSURE, X-RAY CATEGORY AND OCCUPATIONAL SUB- GROUPS.

Males

All factories.

Occupational group	Type of Exposure	No of workers				As percentage of all X-ray groups			
		X-ray groups				X-ray groups			
		I	II	III & IV	Total	I	II	III & IV	Total
S 1 Fettler etc	IRON	68	26	16	110	62	24	15	101
	STEEL	122	45	73	240	51	19	30	100
	MIXED	31	7	8	46	67	15	17	99
S 2 Welder etc	IRON	9	5	—	14	64	36	—	100
S 3 Shotblaster	STEEL	41	20	38	99	41	20	38	99
S 6 Labourers etc	MIXED	19	8	1	28	68	29	4	101
S 7 Various occupations in fettling shop	IRON	14	4	1	19	74	21	5	100
	STEEL	23	13	23	59	39	22	39	100
	MIXED	26	15	7	48	54	31	15	100

Table VI (a)

S 3 Shotblasters	IRON	5	5	—	10	50	50	—	100
	STEEL	10	5	7	22	45	23	32	100
	MIXED	7	3	1	11	64	27	9	100

Shotblasters Of 10 shotblasters in iron foundries 5 had normal X ray films and 5 showed [illegible]
nodulati[illegible]
films 5
mixed fc[illegible]
and 1 definite reticulation The observed expected ratios are given in the addendum to Table VII but the figures are too small to be statistically reliable As regards the severe X ray categories (III and IV) the ratio for iron shot blasters is low whereas that for steel and mixed exposures is high This finding though unreliable coincides more or less with clinical and other experience regarding the silicosis and pneumoconiosis risk to sand and shotblasters

(iii) *Various Occupations in the Fettling Shops* This group includes workers who had such a variety of occupations in the fettling shop that they could not [illegible]

and 5 (9 p r cent) had nodulation

[illegible]

were —

	Steel Iron	*Steel – Mixed*
Fettler	(199 ± 34)	(178 ± 46)
Welder etc	(361 ± 84)	(330 ± 64)
Various occupations in the fettling shop	(245 ± 68)	(159 ± 54)

No significant differences were observed between the ratios for different occupations in the fettling shop with like exposures and it therefore seems reasonable [illegible]
and environmental grounds a distinction can be made in individual cases

OTHER WORKERS

[illegible]

TABLE VII. OBSERVED/EXPECTED RATIOS BY TYPE OF EXPOSURE, X-RAY CATEGORY AND OCCUPATION WITHIN THE FETTLING SHOPS.

Males

All factories.

Occupational group	Type of Exposure	X-ray groups			
		I	II	III & IV	Total
S 1 Fettlers etc.	IRON	89	133±23	(112±26)	100
	STEEL	69	115±16	311±21	100
	MIXED	97	(88±35)	(133±41)	100
S 2 Welders, S 3 *Shotblasters*, S 6 Labourers etc	IRON	88	(228±68)	*(0±79)*	*100*
	STEEL	*57*	*118±25*	361±31	100
	MIXED	95	(167±46)	(31±56)	100
S 7 Various occupations in fettling shop	IRON	109	*(125±56)*	*(34±58)*	*100*
	STEEL	59	(112±29)	279±35	100
	MIXED	79	165±33	(120±42)	100
Total	IRON	92	140±20	(90±23	100
	STEEL	65	116±12	317±15	100
	MIXED	89	137±21	(107±26)	100

TABLE VII (a)

S 3 Shotblasters	IRON	(73)	(300±78)	(0±85)	100
	STEEL	61	(144±54)	(319±68)	100
	MIXED	(84)	(164±74)	(117±108)	*100*

TABLE VIII DISTRIBUTION OF OTHER WORKERS BY TYPE OF EXPOSURE X RAY CATEGORY AND OCCUPATIONAL SUB GROUP

Males

All factories

Occupational group	Type of Exposure	No of workers				As percentage of all X ray groups			
		X ray groups				X ray groups			
		I	II	III & IV	Total	I	II	III & IV	Total
Coreshop workers	IRON	48	4	—	52	92	8	—	100
	STEEL	32	7	2	41	78	17	5	100
	MIXED	55	8	2	65	85	12	3	100
Pattern shop workers	IRON	49	4	1	54	91	7	2	100
	STEEL	15	8	—	23	65	35	—	100
	MIXED	69	3	—	72	96	4	—	100
Maintenance workers	IRON	48	5	—	53	91	9	—	100
	STEEL	138	12	7	157	88	8	5	101
	MIXED	90	9	1	100	90	9	1	100

2 (3 per cent) had reticulation

(ii) *Pattern Shop Workers* This is a group exposed mainly to wood dust, (see description of foundry processes) the pattern shops usually being quite separate from the moulding and fettling shops It is all the more surprising therefore to find that examination of the pattern makers reveals the presence

and 8 (35 per cent) had early reticulation There were no cases of reticulation or nodulation *In mixed foundries 72 pattern makers were examined, 69* (96 per cent) of these had normal films and 3 (4 per cent) had early reticulation Again, there were no cases in X-ray categories III and IV

(iii) *Maintenance workers etc* In this group also the steel factory workers showed a higher incidence of abnormal X-ray changes The group consists of *people who are exposed intermittently to the dust in the general atmosphere of* the factories The figures as shown in Table VIII are —of 53 workers in iron foundries 48 (91 per cent) had normal films whereas 5 (9 per cent) had early

... in Table IX Both this and

workers with steel exposure, the ratio 261 ± 57 exceeds the corresponding ratio for iron workers by 212 ± 67 and for "mixed" exposures by 236 ± 64 The same ratio is similarly responsible *for the only significant* differences to be

SUMMARY OF RESULTS OF OCCUPATIONAL ANALYSIS

group is less than for iron or mixed exposures

TABLE IX

OBSERVED/EXPECTED RATIOS BY TYPE OF EXPOSURE, X RAY CATEGORY AND OCCUPATION WITHIN OTHER WORKERS' GROUP

Males | All factories

Occupational group	Type of Exposure	X ray groups			
		I	II	III & IV	Total
Coreshop workers	IRON	127	(46±34)	0±42	100
	STEEL	102	(112±40)	(61±55)	100
	MIXED	124	(68±29)	23±34	100
Pattern shop workers	IRON	120	(49±35)	20±44	100
	STEEL	82	(261±57)	(0±79)	100
	MIXED	133	25±29	0±35	100
Maintenance workers etc	IRON	130	(57±34)	0±40	100
	STEEL	113	53±21	56±28	100
	MIXED	122	52±24	11±33	100
Total	IRON	125	51±20	6±24	100
	STEEL	108	85±18	52±24	100
	MIXED	126	49±16	12±20	100

The distribution by X ray classification was found to differ technically between occupations for like exposures when examined from the broad occupational aspect

When the occupational groups were examined in more detail it was concluded that whereas the sub-groups for the fettling shops gave very similar

other type of exposure for severe X ray abnormality this occupation followed the general trend

that the analysis of the sub groups has sometimes depended on rather doubtful figures

The following selection of all significant ratios for X ray group II from Tables V, VII, and IX shows the relative liability of workers to develop early X ray reticulation in those occupations for which reasonable data are available

Occupation	*Type of exposure*	*Deviation of ratios from* 100	*Deviation – standard error*
Moulders etc.	Steel	48 ± 16	2 9
Moulding Shop labourers etc	Mixed	82 ± 33	2 5
Knock out men etc	Steel	60 ± 28	2 1
Pattern Shop workers	*Mixed*	*–75 ± 29*	*2 6*
Maintenance workers	Steel	–47 ± 21	2 2

A similar arrangement of the significant ratios obtained for X ray groups III and IV combined gives

Occupation	*Type of exposure*	*Deviation of ratios from* 100	*Deviation – standard error*
Fettlers	Steel	211 ± 21	10 2
Welders etc	Steel	261 ± 31	8 5
Mixed occupations in fettling shop	Steel	179 ± 35	5 1
Mixed occupations in moulding shop	Iron	–55 ± 25	–2 2
Moulders etc	Iron	–36 ± 15	–2 5
Coreshop workers	Mixed	–77 ± 34	2 3
Coreshop workers	Iron	–100 ± 42	–2 4
Pattern Shop workers	Mixed	–100 ± 35	–2 8
Maintenance workers	Mixed	89 ± 33	2 7
Maintenance workers	Iron	–100 ± 40	–2 5

While these ratios show that the incidence of X ray abnormalities in each ... national sub-groups differs significantly from the incidence in

steel factories

ABNORMAL X-RAY APPEARANCES OF THE LUNGS OF YOUNG FOUNDRY WORKERS

A noticeable finding was the high incidence of early reticulation (X ray Category II) in young workers with short exposures to foundry conditions.

Possible explanations for this finding are

(i) that young workers have greater vital capacities than older ones and therefore more air with air-borne dust is taken into their lungs

(ii) that young workers are less careful than their seniors to avoid dust clouds

(iii) that the abnormal X-ray appearances may represent congestive changes set up by a "foreign body" reaction caused by the dust in the lungs. This reaction is likely to be more active in younger workers

(iv) *that the lungs of young workers are more susceptible to the action of free* silica on the lung tissues It is known that people between 15 and 25 years of age are more prone than other age groups to contract pulmonary tuberculosis

COMPARISON OF X-RAY CLASSIFICATIONS FOR INDIVIDUAL FACTORIES

Comparison between the factories is made difficult by the absence of any strict sampling plan at the beginning of the inquiry In many cases the number of workers representing a specific type of exposure or occupation in any one factory is small, apart from the fact that the sample might be selective Table I shows the number of men and women employed in each occupation and the numbers examined. In the following discussion the broad occupational groups only have been used in an attempt to overcome the first disadvantage, and the analysis has been limited to those occupational and exposure groups with more than 20 subjects Even so, all conclusions must be tentative

have arisen by chance The differences are

A	47 ± 22
B	88 ± 30
C	−72 ± 27
K	−165 ± 59

These differences may be due partially or entirely to any of the following reasons

(i) the occupational construction of the moulding shop group in these factories (e g relatively more furnace workers than 'mixed' occupation men would probably tend to decrease the ratios).

(ii) the sample used for each factory may not be reasonably representative of that factory,

(iii) a real difference exists between factories in the incidence of X-ray group II

TABLE X DISTRIBUTION OF IRON EXPOSED SUBJECTS BY X RAY CATEGORY OCCUPATION AND FACTORY (EXCLUDING ALL FACTORIES WITH 20 OR LESS SUBJECTS IN A GROUP)

MALES

FACTORY	No of Workers				As Percentage of all X ray Groups			
	I	II	III & IV	Total	I	II	III & IV	Total
			MOULDING SHOP WORKERS					
A	109	14	10	133	82	11	8	101
B	65	2	5	72	90	3	7	100
C	64	27	—	91	70	30	—	100
D	30	4	—	34	88	12	—	100
E	36	2	—	38	95	5	—	100
G	27	6	2	35	77	17	6	100
K	7	8	14	29	24	28	48	100
R	22	8	4	34	65	24	12	101
S	53	5	5	63	84	8	8	100
			FETTLING SHOP WORKERS					
A	37	9	10	56	66	16	18	100
S	15	5	1	21	71	24	5	100
			OTHER WORKERS					
A	47	1	—	48	98	2	—	100

TABLE XI OBSERVED/EXPECTED RATIOS FOR IRON EXPOSED SUBJECTS BY X RAY CATEGORY OCCUPATION FACTORY (EXCLUDING ALL FACTORIES WITH 20 OR LESS SUBJECTS IN A GROUP)

FACTORY	X ray Groups			
	I	*II*	*III & IV*	*Total*
		MOULDING SHOP WORKERS		
A	123	57±20	51±23	100
B	130	16±28	52±32	100
C	93	176±26	0±38	100
D	126	(67±41)	(0±49)	100
E	139	28±38	(0±45)	100
G	119	(87±38)	(37±43)	100
K	29	269±58	791±75	100
R	94	(129±40)	(94±48)	100
S	117	48±31	(70±38)	100
		FETTLING SHOP WORKERS		
A	100	(84±31)	(121±35)	100
S	103	(140±53)	(35±60)	100
		OTHER WORKERS		
A	135	13±36	0±44	100

Possibility (ii) seems unlikely in the case of factory K where out of 34 moulding shop workers who composed the population at the time of the investigation, 31 persons were examined with a predominantly foundry work history, similarly in factory B 80 out of a possible 89 were examined

Only moulding shop workers in factory K experienced a different incidence of the severe abnormalities from those of all factories (55 ± 11) and this difference (736 ± 76) strengthens the argument that this factory presents a rather different picture from the rest (The most likely explanation for the difference lies in the fact that small castings such as iron hinges were made Each moulder made 150 boxes of such castings during a shift and on each box silica parting powder was dusted from a calico bag Two dustings on each box were made so that the moulders were exposed to the inhalation of 300 dust clouds per day, largely composed of free silica particles At the other factories larger castings were made, and parting powder would not have to be applied so often In some foundries parting sand and not powder was used In the section on pathology 3 fatal cases of silicosis from factory K will be described)

Study of the crude figures of incidences of X ray abnormalities amongst moulding shop workers (Table X) in 9 iron foundries shows that the percentages of films classified as normal (I) varied from 24 to 95 of those classified as early reticulation (II) from 5 to 30 whereas for the combined categories of reticulation and nodulation (III and IV) the percentage incidences varied from 0 to 48 In fettling shop workers in 2 iron foundries there were 66 and 71 per cent with normal films 16 and 24 per cent with early reticulation and 5 and 18 per cent with reticulation and/or nodulation

TABLE XII DISTRIBUTION OF STEEL EXPOSED SUBJECTS BY X RAY CATEGORY OCCUPATION AND FACTORY (EXCLUDING ALL FACTORIES WITH 20 OR LESS SUBJECTS IN A GROUP)

MALES

FACTORY	No of Workers				As Percentage of all X ray Groups			
	I	II	III & IV	Total	I	II	III & IV	Total
MOULDING SHOP WORKERS								
M	68	29	11	108	63	27	10	100
N	66	19	25	110	60	17	23	100
P	98	32	17	147	67	22	12	101
R	69	29	11	109	63	27	10	100
S	21	1	2	24	88	4	8	100
FETTLING SHOP WORKERS								
M	39	13	33	85	46	15	39	100
N	23	20	20	63	37	32	32	101
P	90	26	54	170	53	15	32	100
R	23	17	26	66	35	26	39	100
OTHER WORKERS								
M	17	7	2	26	65	27	8	100
N	21	6	3	30	70	20	10	100
P	144	14	4	162	89	9	3	101

TABLE XIII OBSERVED/EXPECTED RATIOS FOR STEEL EXPOSED SUBJECTS BY X-RA[Y] CATEGORY, OCCUPATION AND FACTORY (EXCLUDING ALL FACTORIES WITH 20 [OR] *LESS SUBJECTS IN A GROUP*)

MALES

FACTORY	X-ray Groups I	II	III & IV	Total
		MOULDING SHOP WORKERS		
M	86	159±23	(104±31)	100
N	88	(95±22)	167±26	100
P	93	131±20	(102±25)	100
R	89	149±23	(91±29)	100
S	118	(27±52)	(84±65)	100
		FETTLING SHOP WORKERS		
M	61	(96±27)	416±36	100
N	53	169±29	267±37	100
P	71	97±19	338±25	100
R	52	(132±63)	284±33	100
		OTHER WORKERS		
M	78	(283±64)	(117±77)	100
N	104	(96±40)	(83±53)	100
P	113	62±21	34±29	100

... ed to show

fettlmg shop and other workers with the e...
factory M. In this factory the ratio of X-ray group II for "other workers" ... aggregate (85 ± 18) by −198 ± 66, and a

... ives a truer picture

... M, N and P it is possible to compare the effects of ... steel exposure (as ... perience that broad ... Of the three

together; the ratios for factories M, N and P, (and the ... suggestive) follow the aggregate pattern except that the differences between

moulding shop and other" workers are in no case significant The significant differences obtained were —

Factory	Fettling shops – moulding shops	Fettling shops – "others"
M	(312 ± 47)	(299 ± 84)
N	100 ± 45	(184 ± 64)
P	(236 ± 35)	(304 ± 39)
R	(193 ± 44)	No comparison possible

These ratios mean of course that in these factories the workers in the fettling shops are more liable to develop the advanced X ray changes, reticulation and

TABLE XIV DISTRIBUTION OF MIXED EXPOSED SUBJECTS BY X RAY CATEGORIES, OCCUPATION AND FACTORY (EXCLUDING ALL FACTORIES WITH 20 OR LESS IN A GROUP)

MALES

FACTORY	No of Workers				As Percentage of all X ray Groups			
	I	II	III & IV	Total	I	II	III & IV	Total
			MOULDING SHOP WORKERS					
C	16	8	2	26	6?	31	8	101
N	18	6	11	35	51	17	32	100
P	21	7	6	34	62	21	18	101
R	28	7	2	37	76	19	5	100
S	152	11	5	168	91	7	3	101
			FETTLING SHOP WORKERS					
S	46	12	5	63	73	19	8	100
			OTHER WORKERS					
P	21	4	1	26	81	15	4	100
R	91	11	—	102	89	11	—	100
S	69	1	1	71	97	1	1	99

(III) *Mixed exposures group* For the mixed exposures an examination of factory S in each occupational group and of C, N, P and R, in the moulding shop workers' group and of P and R in the 'other workers' group is possible (Tables XIV and XV) Within each X ray and occupational group the ratios do not differ significantly from those of all factories in the co[illegible]ding gr[illegible] except that for X ray groups III and IV the [illegible] rs of [illegible] N have a much higher ratio (difference [illegible] he shop workers combined.

Comparison of the occupational groups for all factories combined limited to mixed exposures showed an association between X ray classification and broad occupational grouping From Table XV a complete comparison can be made only for factory S and this shows for X ray group II no sign ficant difference bet veen mo ld

excess c

over mc [illegible] in X ray groups III and IV no significant difference between occupations at factory S is evident

TABLE XV OBSERVED/EXPECTED RATIOS FOR MIXED EXPOSED SUBJECTS BY X RAY CATEGORY OCCUPATION AND FACTORY (EXCLUDING ALL FACTORIES WITH 20 OR LESS IN A GROUP)

MALES

FACTORY	X ray Group			
	I	II	III & IV	Total
		MOULDING SHOP WORKERS		
C	98	(163±45)	(43±46)	100
N	83	(81±37)	190±42	100
P	97	(101±38)	(111±43)	100
R	114	(98±37)	(38±43)	100
S	121	41±19	33±26	100
		FETTLING SHOP WORKERS		
S	99	(120±32)	(74±39)	100
		OTHER WORKERS		
P	114	(87±47)	(34±59)	100
R	125	61±24	0±30	100
S	125	10±31	19±43	100

STATISTICAL ANALYSIS OF X RAY RESULTS CONCLUSIONS

It is seen that the make-up of the various factory samples (Table I) for example by occupation varies considerably particularly in the case of other workers The data therefore cannot be accepted as completely representative of the total factory populations Further in many of the groups studied the numbers are of necessity small In spite of these obvious drawbacks it is considered that the following points are justified as suggestions from the foregoing analysis

1 T[illegible]

a reduced incidence amongst labourers

2 Incidence of severe abnormalities is greatest amongst steel workers

3 There are few occupations ın the sub-dıvısıons which dıffer ın their ıncı dence of X ray group II from the maın occupatıonal groups of which they form part Thus amongst ıron foundry workers ıt was found that furnacemen etc experıenced relatively more frequent classıficatıon to thıs group than d d the

trends and the adverse effects of fettlıng shop actıvıty and steel exposure ıs demonstrated ın compar son wıth other combınatıons at most ages and lengths of exposure stud ed

TABLE XXIX NUMBER AND PROPORTION OF SUBJECTS TAKING EXERCISE TOLERANCE TEST AND FAILING TO PASS STANDARDS A AND B BY TYPE OF EXPOSURE AND X RAY CATEGORY

MALES

Type of Exposure	Test*	Number of subjects				As percentage of N*			
		X ray Group				X ray Group			
		I	II	III & IV	To al	I	II	III & IV	Total
IRON	N	370	96	33	499	—	—	—	—
	A	249	52	18	319	67	54	55	64
	B	158	6	8	19	43	27	24	39
STEEL	N	618	189	190	997	—	—	—	—
	A	371	1 0	107	598	60	64	56	60
	B	180	61	63	304	29	32	33	31
MIXED	N	257	62	32	351	—	—	—	—
	A	144	38	14	196	56	61	44	56
	B	76	22	11	109	30	36	34	31
TOTAL	N	1,245	347	255	1 847	—	—	—	—
	A	764	210	139	1 113	61	61	55	60
	B	414	109	82	605	33	31	32	33

* N = Total No of ınd v dua s takıng test
* A = No fa l ng test because thırd read ng exceeded + 5 beats per m nute of the f rst
* B = No fa lıng test because of A and the second readıng exceedıng 100 beats per mınute

(iii) RESULTS OF EXERCISE TOLERANCE TESTS

It was decided to employ two criteria of failure to pass the test Men failed if –

(a) The third pulse rate was not within $+5$ beats per minute of the first, or
(b) The third pulse rate was not within $+5$ beats per minute of the first and

34 men would not invalidate any conclusions on a comparison between X ray classification and inability to pass the test

The crude proportions failing the test are shown in Table XXIX by X ray grouping and type of exposure Direct comparison between workers in iron

X-ray and exposure groups

TABLE XXX OBSERVED/EXPECTED RATIOS OF NUMBER OF SUBJECTS FAILING TO PASS EXERCISE TOLERANCE TEST BY STANDARDS A AND B BY TYPE OF EXPOSURE AND X-RAY CATEGORY

MALES

Type of Exposure	X ray Group			
	I	II	III & IV	Total
		TEST A		
Iron	112± 7	93±13	(94±23)	107± 4
Steel	98± 5	106± 9	98±10	99± 4
Mixed	92± 8	101 16	(76±23)	92± 7
Total	101± 4	101± 7	95± 8	100
		TEST B		
Iron	127± 9	81±18	(86±33)	116± 8
Steel	90± 7	102±13	104±13	95± 6
Mixed	86±11	111±23	(112±32)	92± 9
Total	100± 5	98±10	103±11	100

The data were then standardised for age and length of exposure as described under Statistical Methods, (page 24) and the standardised ratios for ... are shown in Table XXX If any relationsh... failure to pass the test, an increas... expected as one moved from nor... malities This trend, shown by a... sistent for steel and m... iron work... from grou... is no defin... the better... X-ray grou... for iron workers... both criteria there ... criterion (b) is workers, but in X-ray gro... than for either ... there are more fa... except

I ... test criterion ... differences between X-ray groups for between groups I and II for iron workers are not statistically significant except that 46 ± 20) ... assessed by criterion (b), (difference

(iv) RESULTS OF SPIROMETRY

A satisfactory measurement of vital capacity was made for ... ects X-rayed, and although no ... no reason to believe ... ssess the relationship ... mparisons have thus ... to like groups of ... vital capacity, and groups III and IV have been combined to overcome small numbers since of the 1,604 subjects for whom the measurement was available, only 26 were classified as X-ray group IV (two iron workers, 20 steel and 4 mixed iron and steel workers)

Table XXXI shows the mean and standard deviat... with the number of subjects examined in e... These crude figures show a decrease in vit... X-ray group for iron and for steel workers ... steel exposure, the combined X-ray group ... figure than X-ray group II, but both are l... X-ray group I

These crude figures are very suggestive but, just as age and length of exposure influence X-ray classification, it is probable that these factors influence vital capacity, in which case the progressive reduction of ... normal to abnormal X ray gr... age or length of expos... of exposure upon vita... the 1,604 measurement...

$Y = 4098\ 1913 - 23$ ... $X_1 + 2\ 5951\ X_2$ ... was obtained — ... culated vital capacity in cubic centimetr... (1) where Y is the cal-

X_1 is the age in years

X_2 is the length of exposure in years

An analysis of variance shows that the relationship ... (variance ratio $= 12\ 44$ $P < 0\ 00$... regression line as a ... of exposure The a... length of exposu...

P <0 001), but whereas the regression coefficient for age (b_1 = −23 8015) ex

the consideration then the equation becomes —

$Y = 4082\ 2794 - 22\ 3634\ X$ (2) where Y is the estimated vital capacity in c cs and X is the age in years

TABLE XXXI MEAN VITAL CAPACITY IN CUBIC CENTIMETRES BY X-RAY GROUP AND TYPE OF EXPOSURE

Type of *Exposure*		X ray Group			
		I	II	III & IV	Total
Iron	No of observations	335	96	31	462
	Mean	3,273	2,965	2,590	3 163
	Standard deviation	783	703	851	796
Steel	No of observations	517	158	152	827
	Mean	3,294	3 170	3,078	3,231
	Standard deviation	733	783	800	759
Mixed	No of observations	327	58	30	315
	Mean	3,131	2,838	2 880	3 035
	Standard deviation	789	710	819	786
Total	No of observations	1,079	312	213	1,604
	Mean	3,253	3,045	2 979	3,176
	Standard deviation	763	756	825	777

Analysis of variance again shows that the relationship is probably non-linear (variance ratio = 11 50, P <0 001) and again reveals the existence of the ... (variance ratio = 248 77 P <0 001)

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ABLE XXXII MEAN OBSERVED AND 'EXPECTED' VITAL CAPACITY IN CUBIC CENTIMETRES BY X RAY GROUP AND TYPE OF EXPOSURE

Type of Exposure		X ray Group I	II	III & IV	Total
Iron	No of observations	335	96	31	462
	Observed mean	3,273	2,965	2,590	3,163
	Expected mean *	3 158	3,046	2,926	3,119
	'Observed-expected'	115	−81	−336	44
	Standard error	40	74	130	34
Steel	No of observations	517	158	152	827
	Observed mean	3 294	3,170	3 078	3 231
	Expected mean*	3,287	3,142	3,077	3,221
	Observed-expected	7	28	1	10
	Standard error	32	58	59	25
Mixed	No of observations	227	58	30	315
	Observed mean	3,131	2,838	2,880	3 053
	Expected mean*	3,185	3,072	2,964	3,143
	Observed-expected	−54	−234	−84	−90
	Standard error	48	95	132	42
Total	No of observations	1 079	312	213	1,604
	Observed mean	3,253	3,045	2,979	3,176
	Expected mean*	3,225	3 099	3,039	3,176
	Observed-expected	28	−54	−60	0
	Standard error	22	41	50	18

* 'Expected' values are obtained from the regression line, $y = 4082.2794 - 22.3634\,x$, where y is vital capacity in cubic centimetres and x = age in years

The crude data of Table XXXI was subjected to this treatment and the results are shown in Table XXXII In the iron exposure group the deviation (115 c c)

capacity less than that expected (observed-expected = 81 ± 74) and groups III and IV show a further reduction (observed-expected = −336 ± 130) It would

The data for each type of exposure were then sub-divided into the three

the vital capacity of abnormal compared with normal subjects (difference — 85 ± 39) A similar reduction is observed for all occupations combined in

For mixed iron and steel workers the difference is significant among fettling shop workers (550 ± 291) In the steel exposure group, there is no significant difference between the normal and abnormal subjects in any occupational groups

of mean vital capacity show a general reduc- each of the three types of ex- tion is closely associated with

In the fettling shop

posure group

TABLE XXXIII MEAN OBSERVED AND EXPECTED VITAL CAPACITY IN CCS BY OCCUPATION X RAY CLASSIFICATION AND TYPE OF EXPOSURE

Type of Exposure		Moulding Shop Workers			Fettling Shop Workers			Other Workers			Total		
		X ray Classification											
		Normal	Ab-normal	Total	Normal	Ab-normal	Total	Normal	Ab-normal	Total	Normal	Ab-normal	Total
Iron	No of observations	217	77	294	54	37	91	64	13	77	335	127	462
	Observed mean	3 287	2 895	3 184	3 215	2 765	3 032	3 275	3 054	3 238	3 273	2 873	3 163
	Expected* mean	3 153	3 005	3 114	3 146	3 014	3 092	3 184	3 089	3 168	3 158	3 016	3 119
	Obs Exp	134	110	70	69	249	60	91	35	70	115	−143	44
	Standard Error	49	82	42	99	119	76	90	201	83	40	64	34
Steel	No of observat ons	224	124	348	132	159	291	161	27	188	517	310	827
	Observed mean	3 167	3 039	3 121	3 400	3 188	3 284	3 384	3 144	3 350	3 294	3 124	3 231
	Expected mean	3 265	3 089	3 202	3 297	3 140	3 211	3 312	3 028	3 271	3 287	3 110	3 221
	Obs Exp	98	−50	−81	103	48	73	72	116	79	7	14	10
	Standard Error	48	65	39	63	57	42	57	139	53	32	41	25
Mixed	No of observat ons	98	49	147	26	22	48	103	17	170	227	88	315
	Observed mean	3 124	3 022	3 090	3 261	2 636	2 975	3 104	2 641	3 038	3 131	2 852	3 053
	Expected Mean	3 118	3 013	3 083	3 171	3 096	3 137	3 251	3 020	3 218	3 184	3 035	3 143
	Obs Exp	6	9	7	90	460	162	147	379	−180	−54	183	−90
	Standard Error	73	103	60	142	154	104	71	176	66	48	77	41
Total	No of observat ons	539	250	789	212	218	430	328	57	385	1 079	525	1 604
	Observed mean	3 208	2 991	3 139	3 336	3 061	3 196	3 275	2 973	3 230	3 253	3 018	3 176
	Expected mean	3 193	3 048	3 147	3 243	3 114	3 178	3 268	3 040	3 234	3 225	3 075	3 176
	Obs Exp	15	−57	−8	93	−53	18	7	−67	−4	28	−57	0
	Standard Error	31	46	26	50	49	35	40	96	37	22	32	18

* Expected values are obta ned from the regress on line y = 4082 2794 22 3634 x where y is the vital capacity in ccs and x the age in years

TABLE XXV NUMBER AND PROPORTION OF SUBJECTS WITH PAST HISTORY OF PNEUMONIA DURING THEIR EXPOSURE, BY TYPE OF EXPOSURE, AND X RAY CLASSIFICATION

Males — All Factories*

Type of Exposure	No of subjects for whom past histories were available				Subjects with history of Pneumonia during period of exposure							
					Number				As percentage of exposed to risk			
	X ray Group				X ray Group				X ray Group			
	I	II	III & IV	Total	I	II	III & IV	Total	I	II	III & IV	Total
Iron	684	151	46	881	35	15	5	55	5	10	11	6
Steel	696	215	209	1 120	29	12	7	48	4	6	3	4
Mixed	587	99	48	734	23	9	5	37	4	9	10	5
Total	1 967	465	303	2,735	87	36	17	140	4	8	6	5

* Excluding Factory K.

(v) INCIDENCE OF PNEUMONIA AND PLEURISY

Information about previous illnesses was obtained for all subjects except the 32 employed at factory K. Table XXV shows the proportion in each exposure and X-ray group who admitted having had an attack of pneumonia during their working life in the industry Of 2,735 workers, 140 (5 per cent) had had pneumonia, the incidence rate being 6 per cent of those who had worked in iron foundries, 4 per cent in steel and 5 per cent in mixed iron and steel Of the iron workers in X-ray category I, 5 per cent had a history of pneumonia; 10 per cent of II and 11 per cent of III and IV For steel workers the figures were 4, 6 and 3 per cent respectively whereas in mixed iron and steel foundries the percentages were 4, 9 and 10 These crude figures do suggest for iron and mixed exposures some association with X ray classification but it was found that their direct use was misleading since the different age and length of exposure constitution of the various groups greatly affected the pneumonia incidence rates Table XXVI shows the results after standardisation for these two factors by a procedure similar to that adopted in the previous section on X-ray classification The number of "expected" positive histories is the number to be expected in any specific X-ray and/or exposure group when the prevailing pneumonia incidence rates for specific age and length of exposure groups were those observed for all types of exposure and X ray classification combined The standard errors in this table (and in XXII) have been included for all X-ray groups since the values of "q" (see Chapter III, p 25) can be considered as small throughout, and thus the use of the approximate form of the standard error is similarly justified

TABLE XXVI OBSERVED/EXPECTED RATIOS OF SUBJECTS WITH PREVIOUS HISTORY OF PNEUMONIA BY TYPE OF EXPOSURE AND X-RAY CLASSIFICATION

Males

Type of Exposure	X ray Group			All factories*
	I	II	III & IV	Total
Iron	98±17	(145±31)	(147±54)	111±14
Steel	109±19	(105±30)	54±28	94±14
Mixed	78±19	(142±40)	(131±51)	94±16
Total	95±10	128±19	(84±22)	100

* Excluding Factory K

Amongst the normal X-ray subjects, though the ratio is highest for the steel group, it is not significantly so In the remaining groups most of the ratios are suspect and in no case is there a difference between types of exposure within X-ray groups or between X-ray groups within type of exposure which can be considered larger than could easily have arisen by chance In spite of the fact that these ratios are not statistically significant, their pattern suggests that this subject is one worthy of more detailed study with larger numbers of observations and with controls from other occupations The interesting trend is, of course, that the steel exposure group, unlike the iron and "mixed" groups reveals a diminishing ratio as the X-ray classification deteriorates In other words a

steel worker whose X ray film shows reticulation or nodulation is less likely to have had an attack of pneumonia than his mate whose X ray film is normal A possible explanation is that in the steel trade there is some self selection of

however, that men in the steel trade on the whole have better physical con stitutions than those in many other trades

TABLE XXVII NUMBER AND PROPORTION OF SUBJECTS WITH PAST HISTORY OF PLEURISY DURING THEIR EXPOSURE BY TYPE OF EXPOSURE AND X RAY CLASSIFICATION

Males | All factories*

Type of Exposure	No of subjects for whom past histories were available			Subjects with history of Pleurisy during period of exposure					
				Number			As percentage of exposed to risk		
	X ray Group			X ray Group			X Group		
	I	II III & IV	Total	I	II III & IV	Total	I	II III & IV	Total
Iron	684	197	881	20	3	23	3	2	3
Steel	696	424	1 120	15	14	29	2	3	3
Mixed	*587*	*147*	*734*	12	2	*14*	2	1	2
Total	1 967	*768*	*2 735*	47	*19*	*66*	2	*3*	2

* Excluding Factory K

TABLE XXVIII OBSERVED/EXPECTED RATIOS OF SUBJECTS WITH PREVIOUS HISTORY OF PLEURISY BY TYPE OF EXPOSURE AND X RAY CLASSIFICATION

Males | All factories*

Type of Exposure	X ray Group		
	I	II III & IV	Total
Iron	*121±25*	*(50±41)*	102±21
Steel	(115±28)	(114±29)	114±20
Mixed	(87±27)	(48±49)	(78±24)
Total	108±15	(84±21)	100

* Excluding Factory K

Tables XXVII and XXVIII give similar information for past histories of pleurisy. The numbers involved are so few that these have been combined for each exposure group, even so, very few of the ratios obtained for this disease are based on more than 20 observed patients and, as is to be expected, no s g-nificant differences occur between X-ray groups or exposure groups There

(vi) INCIDENCE OF TUBERCULOSIS

Amongst the 2,767 male foundry workers, there were 10 cases (0 36 per cent) of active pulmonary tuberculosis, 23 (0 8 per cent) quiescent and 39 (1 4 per cent) healed tuberculosis. The cases classified as active had clinical and/or

The distribution of cases of tuberculosis is shown in Table XXXIV, which is divided into two parts, A and B

TABLE XXXIV DISTRIBUTION OF TUBERCULOSIS

A Type of Exposure	Healed		Quiescent		Active		Total	
	Simple	+ Group iv	Simple	+ Group iv	Simple	+ Group iv	Simple	+ Group iv
Iron	12	1	1	—	2	2	15	3
Steel	11	1	16	1	3	1	30	3
Mixed	14	—	3	2	1	1	18	3
Total	37	2	20	3	6	4	63	9
B Moulding shop	21	1	6	—	3	2	30	3
Fettling shop	7	1	6	2	2	2	15	5
Others	9	—	8	1	1	—	18	1
Total	37	2	20	3	6	4	63	9

each of these groups is further sub-divided into simple tuberculosis and tuberculosis associated with X-ray Category IV, i.e. nodulation and/or massive

3	Birmingham	(15,700) = 3 6 cases per 1,000
4.	Glasgow	(30,652) = 5 9 cases per 1,000
5.	M R C.	(10,103) = 4 0 cases per 1,000
6.	*Northamptonshire*	*(38,632)* = 4 4 cases per 1,000
	Northamptonshire Boot and Shoe Trade	(17,436) = 5 7 cases per 1,000
7	Present foundry survey	(2,767) = 3.6 cases per 1,000

* Figures in brackets represent total numbers examined in each survey.

(vii) RESULTS OF CLINICAL EXAMINATION*

In view of the general tendency to regard clinical examinations as not being

and pyrexia characteristic of the disease. We think ...

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working in the same room and there would often be a race ... keep

... at one made

complete information was obtained from them than from those at the other foundries

TABLE XXXV DISTRIBUTION OF COUGH IN RELATION TO X RAY CHANGES

X ray signs	Moulding Shop		Fettling Shop		
	Cough	No Cough	Cough	No Cough	Totals
Normal	32	39	17	21	109
Increased linear striation	2	3	2	1	8
Early Reticulation	6	5	8	2	21
Reticulation	8	4	15	11	38
Nodulation	—	—	8	—	8
Massive shadows	—	—	4	1	5
Tuberculosis	1	—	2	—	3
Totals	49	51	56	36	192

It will be seen that no clear relationship exists between the symptom of cough and the X ray picture, though all 8 cases with X ray films showing nodulation, 4 out of 5 with massive shadows and all 3 cases of tuberculosis, complained of cough

(ii) *Sputum* If a worker complained of cough, he often said that he brought up sputum as well, but this was not necessarily the case Some complained of cough without expectoration, whereas more of them said that they brought

up sputum but had no cough In those workers who complained that they brought up sputum without coughing, the usual story was that they had to expectorate to get rid of the "muck" on their chests In these cases the sputum was black Typical replies to questions on the point were as follows —

1
2
3
4
5
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7
8 *Grinder*
9 *Electric*
10 *Mouldin*

ter working in the

was present

Tubercle bacilli were found in 4 men, 2 of whom had been diagnosed *clinically as having pulmonary tuberculosis One of them, aged 39 years, had*

of pulmonary tuberculosis, and his X ray films showed

i e, early silicosis Subsequent examinations of the sputum failed to reveal the presence of tubercle bacilli

In two other cases presenting X-ray shadows suggesting healed tuberculous lesions, tubercle bacilli were not found The remaining 45 cases also had no tubercle bacilli in the sputum Some of these cases had X ray signs of *reticulation, nodulation and massive shadows.*

Iron-containing phagocytes, the specimens of sputum were also examined for the presence or absence *of particles of iron either intracellular (i e, inside* phagocytes) or extra cellular stainable by the Prussian blue method The reason for this examination is that it is known *that electric arc welders and* oxyacetylene burners inhale a good deal of iron oxide in finely particulate

cemen, and even *fettlers*

men at this factory (M)

workers

Intracellular iron particles were found in the sputa of 3 fettlers, a slinger

iron containing phagocytes in the sputum

age of each group

TABLE XXXVI DISTRIBUTION OF CASES COMPLAINING OF DYSPNOEA

Length of Employment	Moulding Shop	Average Age	Fettling Shop	Average Age
1 Up to 10 years	6 out of 49 (12 2%)	25 5 years	19 out of 58 (32 7%)	35 2 years
2 11 – 20 years	6 out of 18 (33 3%)	32 3 years	9 out of 21 (42 8%)	36 6 years
3 21 – 30 years	4 out of 22 (18 2%)	41 7 years	2 out of 6 (33 3%)	46 3 years
4 Over 30 years	8 out of 15 (53 3%)	58 4 years	4 out of 4 (100%)	53 5 years
Totals	24 out of 104 (23%)	35 2 years	34 out of 89 (38 2%)	37 1 years

It will be observed that the incidence of dyspnoea was higher in the fettling shop workers ... The average age of the fettling shop workers was

these men had X ray signs of silicosis (nodulation) though some of them had reticulation

up sputum but had no cough In those workers who complained that they brought up sputum without coughing, the usual story was that they had to expectorate to get rid of the "muck" *on their chests* In these cases the sputum was black. Typical replies to *questions on the point were as follows:—*

1

2
3
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7

8 *Grinder.* "[illegible] *tea.*"
9 *Electric*
10 *Mouldin*[illegible] n after working in the foundry No cough

Sputum Examinations Examinations of the sputa were made in 51 selected

presence of tuberculosis (active or quiescent), silicosis and siderosis, (iii) controls from each age group in both moulding and fettling shops if expectoration was present

Tubercle bacilli were found in 4 men, 2 of whom had been diagnosed clinically as having pulmonary tuberculosis One of them, aged 39 years, had

of pulmonary tuberculosis, and his X-ray films showed [illegible] i e, early silicosis Subsequent examinations of the sputum failed to reveal the presence of tubercle bacilli

In two oth[illegible] healed tuberculous lesions, tube[illegible] 45 cases also had no tubercle [illegible] had X-ray signs of reticulation nodulation and massive shadows

[illegible] annels and depots, [illegible] examination of the sputa might give some idea of the amount of [illegible] by various types of workers.

TABLE XXXVII(b) RETICULATION

Moulding Shop				Fettling Shop			
Occupation	Dyspnoea	E.T.T.*	Age	Occupation	Dyspnoea	E.T.T.*	Age
Moulder	−	1	30	Fettler	−	1½	38
Furnace hand	−	1–1½	44	Fettler	−	1–1½	46
Moulder	−	1	45	Fettler	−	1½–2	48
Moulder	−	1	43	Fettler	−	2	61
Moulder	−	1½	38	Fettler	+	1½	46
Moulder	−	1	38	Fettler	−	1	36
Moulder	−	1	41	Fettler	−	1	22
Moulder	+	1–1½	39	Fettler	−	1	24
Furnaceman	−	1	52	Fettler	+	1½	26
Bricklayer's Labourer	+	2	54	Oxyacetylene burner	+	1–1½	42
Moulder	+	2	71	Welder	−	1	40
Moulder	+	2	62	Oxyacetylene burner	−	1	27
Moulder	−	1–1½	58	Sandblaster	+	1½	43
Moulder	−	1	45	Fettler	−	1–1½	37
Moulder	+	1	52	Fettler	−	1	44
				Fettler	+	1½	34
				Fettler	−	1	29
				Welder	−	1	32
				Crane Driver	+	1½	46
				Fettler	+	2	47
				Fettler	−	1	36

* E.T.T. = Exercise Tolerance Test

hand, 2 workers who did not complain of dyspnoea had abnormal exercise tolerance readings (1½ – 2, 2). One was 61 years of age. In general, it can be

RELATIONSHIP OF SYMPTOM OF DYSPNOEA TO RESULTS OF EXERCISE TOLERANCE TESTS AND TO ABNORMAL X-RAY CHANGES

A comparison of the symptom of dyspnoea with the results of exercise tolerance tests and X ray examinations is set out in the following series of tables (XXXVII a – e) All cases with comparable X-ray changes are grouped together The individual ages are also given

TABLE XXXVII(a) EARLY RETICULATION

Moulding Shop				Fettling Shop			
Occupation	Dyspnoea	E T T *	Age	Occupation	Dyspnoea	E T T *	Age
Sandmixer	—	1	44	Fettler	—	1½	36
Sandmixer	—	1	42	Fettler	—	1½	40
Ladleman	—	1	30	Fettler	—	1	43
Labourer	—	1½	51	Fettler	—	1	36
Moulder	+	1½	34	Fettler	+	1½	37
Moulder	—	1–1½	31	Fettler	—	1½–2	50
Moulder	—	1 1½	44	Sandblaster	—	1½	30
Moulder	—	1	43	Fettler	—	1	29
Moulder	—	1	38	Fettler	—	1	25
Moulder	—	1–1½	36	Grinder	+	1½	28
Moulder	+	1	43	Fettler	—	1	27
Moulder	—	1	38				
Moulder	—	1½	68				

* E T T = *Exercise Tolerance Test (See Chapter III page 21)*

[illegible] who had an X ray picture of early reticulation, [illegible] moulder of 68 years, [illegible] 1½) Amongst the 11 [illegible] here were also 2 who [illegible] cise tolerance was 1½ [illegible] had the *same exercise* [illegible] d tolerance to exercise [illegible] t in age was 43 and he had an exercise tolerance of 1 and did not complain [illegible] dyspnoea

TABLE XXXVII(b) RETICULATION

Moulding Shop				Fettling Shop			
Occupation	Dyspnoea	E T T*	Age	Occupation	Dyspnoea	E T T*	Age
Moulder	–	1	30	Fettler	–	1½	38
Furnace hand	–	1–1½	44	Fettler	–	1–1½	46
Moulder	–	1	45	Fettler	–	1½–2	48
Moulder	–	1	43	Fettler	–	2	61
Moulder	–	1½	38	Fettler	+	1½	46
Moulder	–	1	38	Fettler	–	1	36
Moulder	–	1	41	Fettler	–	1	22
Moulder	+	1–1½	39	Fettler	–	1	24
Furnaceman	–	1	52	Fettler	+	1½	26
Bricklayer's Labourer	+	2	54	Oxyacetylene burner	+	1–1½	42
Moulder	+	2	71	Welder	–	1	40
Moulder	+	2	62	Oxyacetylene burner	–	1	27
Moulder	–	1–1½	58	Sandblaster	+	1½	43
Moulder	–	1	45	Fettler	–	1–1½	37
Moulder	+	1	52	Fettler	–	1	44
				Fettler	+	1½	34
				Fettler	–	1	29
				Welder	–	1	32
				Crane Driver	+	1½	46
				Fettler	+	2	47
				Fettler	–	1	36

*E T T = Exercise Tolerance Test

Of the 15 moulding shop workers with X ray pictures of reticulation, 5 complained of dyspnoea, and 3 of these had an exercise tolerance test of 2 (i e , they were definitely short of breath after exercise), but it must be noted that the [illegible]

than 1 In one case the figure for the tolerance to exercise was 2 On the other hand, 2 workers who did not complain of dyspnoea had abnormal exercise tolerance readings (1½ – 2, 2) One was 61 years of age In general, it can be

said of these men with comparable X ray pictures that their tolerance to exercise as is to be expected, decreases with increasing age, but there is no hard and fast rule Another point which can be made is that all men with an X ray picture of reticulation are not necessarily disabled, but that a small proportion of them has some degree of disablement

TABLE XXXVII(c) NODULATION

Fettling Shop*			
Occupation	Dyspnoea	E T T	Age
Fettler	–	1½	42
Fettler	–	1½–2	40
Fettler	+	1 1½	33
Fettler	–	1½	43
Fettler	–	1½–2	43
Welder	–	1	47
Fettler	+	2½	46
Fettler	+	Lame	61

* No cases of X ray nodulation were found amongst the moulding shop workers in Factory M

Only 3 of the 8 fettling shop workers who had X ray pictures of nodulation complained of dyspnoea *but only one of them had a completely normal tolerance to exercise* He was an electric arc welder of 47 years of age The man with the highest reading for the exercise tolerance test (2½) had to give up work

TABLE XXXVII(d) MASSIVE SHADOWS

Occupation	Dyspnoea	E T T	Age
Fettler	+	1	29
Sandblaster	+	4	61
Fettler	+	4	62
Fettler	+	2	45

These 4 cases with massive shadows all complained of shortness of breath, but the first one, a man of 29, had a normal exercise tolerance test and only complained of slight dyspnoea His X-ray film showed nodulation with [illegible]

exercise

TABLE XXXVII(e) TUBERCULOSIS

Occupation	Dyspnoea	E.T.T.	Age
Fettler	+	2	36
Moulder	+	2½	39
Fettler	+	—*	31

* E.T.T not taken

All three cases complained of marked dyspnoea and in the two cases tested, the tolerance to exercise was lowered

(iv) CHEST MEASUREMENT AND EXPANSION

The chest measurement is an indication of the physique of the individual, and the chest expansion – the difference between the measurements at forced inspiration and forced expiration – gives some idea of the mobility of the chest [illegible]

TABLE XXXVIII(a) CHEST EXPANSION

Exposure	Moulding Shop				Fettling Shop			
	No in Group	Average age	Average chest expansion	Variation	No in Group	Average age	Average chest expansion	Variation
Up to 10 years	46	25.5	2.55"	1½" 4"	54	34.1	2.3"	½" – 4"
11 to 20 years	16	32.4	2.25"	1½ – 3"	18	34.5	2.2"	½" – 3½"
21 to 30	22	41.7	2.1"	1½" – 3½"	5	43.2	2.3"	1½" – 3"
Over 30 years	14	57.6	1.68"	1" 3"	4	53.5	1.5"	½" – 2½"

T'

difficult to decide from these figures whether or not the onset of pneumoconiosis also plays a part in decreasing the expansion of the chest, though on clinical evidence we know that it does But when the details are set out in scatter diagrams it can be seen that the chest expansions are not entirely dependent on age

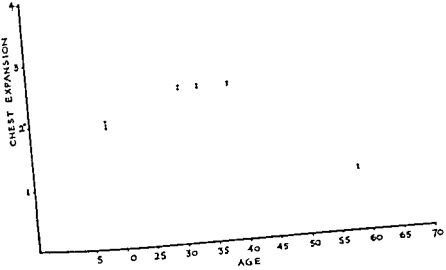
Scatter Diagrams of Chest Expansion and Ages of Workers Diagram I ... ages of the moulding ...op ... 1" ... II, *5 cases are shown to have an expansion of 1" and 3 with ½"* Another case has an expansion of 1¼" Eight of these 9 cases are workers whose ages range from 21 to 46, and 1 with an expansion of ½" is 62 years of age The upper limit of expansion in both groups is 4" and the higher expansions, as would be expected, occur in the younger workers For both groups, which are *comparable in size (89 in moulding shop, 81 in fettling shop), the scatter* ... advancing ... and ... e

The nine fettling shop workers whose chest expansions were 1¼" and under, showed the following X ray changes —

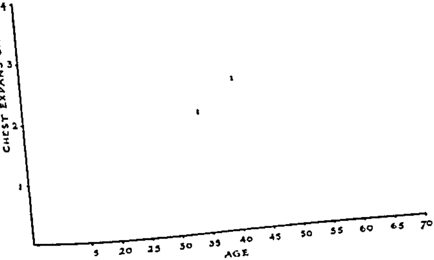
Chest Expansion	*Occupation*	*Age*	*X-ray Diagnosis*
1¼"	Fettler	26	Reticulation
1"	"	46	Reticulo nodulation
1"	"	37	Increased linear markings (otherwise normal)
1"	"	21	*Fine stippling upper ⅔ both lungs*—(otherwise normal)
1"	"	42	Reticulo nodulation
1"	"	43	Reticulation
½"	"	38	Reticulo nodulation
½"	"	36	Reticulation and pulmonary tuberculosis
1"	"	62	No X-ray examination Clinically fibrosis of lungs

Two of these cases had relatively normal X ray appearances in the remainder a diagnosis of pneumoconiosis (1 on clinical grounds) could justifiably be made

SCATTER DIAGRAM I [MOULDING SHOP]
AGE AND CHEST EXPANSION



SCATTER DIAGRAM II [FETTLING SHOP]
AGE AND CHEST EXPANSION



The 3 moulding shop workers who had an expansion of 1" and were X-rayed had the following X-ray appearances:—

Chest Expansion	Occupation	Age	X-ray Diagnosis
1"	Moulder	68	Early reticulation
1"	"	58	Normal
1"	"	57	Normal.

It will be seen that all 3 cases were elderly and that they showed few abnormal X-ray changes. In the 2 cases whose X-ray films were considered to be normal, a preliminary diagnosis of early reticulation was made in each The majority of the interpreters was against such a diagnosis.

Scatter diagrams of Chest Expansions and X-ray Diagnosis. The question of chest expansion can be further studied in more detail by scatter diagrams showing its relation to the X ray appearances For this purpose the following X-ray categories have been adopted, because they appear to give a better idea of the various progressive stages —

Normal,
Increased linear striation,
Early reticulation,
Reticulation,
Reticulo-nodulation,
Nodulation,
Massive Shadows.

The cases of tuberculosis are not included.

Diagram III shows the chest expansions of the moulding shop workers in relation to X-ray changes According to the intensity of the X-ray ... The most advanced category ... ose in the normal and increased ... rying from 1" to 4" but none below 1". Those with early reticulation varied between 1" and 3". In the reticulation category 2 cases had an expansion of 3". The majority had expansions of 1½" and 2"

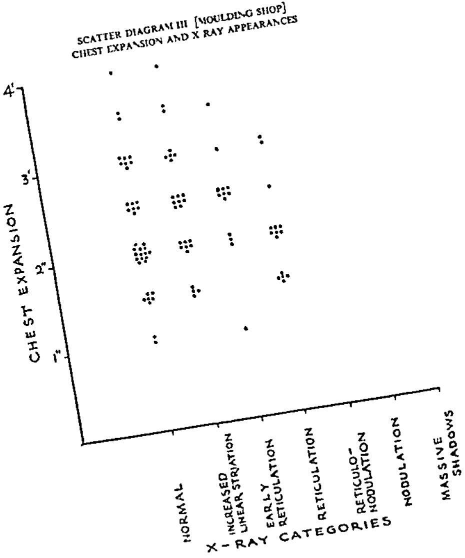
Diagram IV gives the individual chest expansions in the fettling shop workers and shows the same downward trend of expansion as the abnormal X-ray appearances become more intense One case with a 4" expansion showed ...

total
ns of
ously
ettler
years
been
sions
with

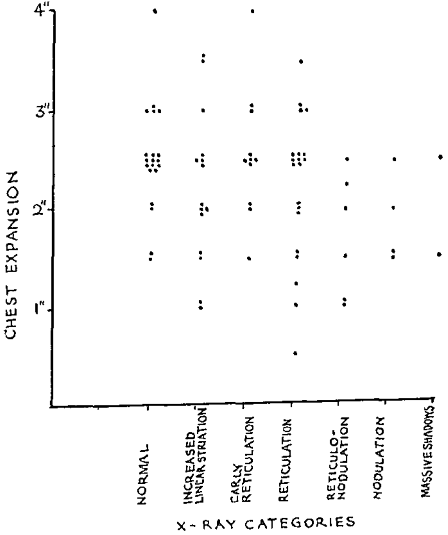
under 1½".

Diagram II

The welders and oxyacetylene burners whose X-ray pictures showed reticu... all had chest expansions of 2½" and over This is to ... hat the X-ray pictures do not represent ... iderosis or aggregates of iron oxide in the


SCATTER DIAGRAM III [MOULDING SHOP]
CHEST EXPANSION AND X RAY APPEARANCES
CHEST EXPANSION
X - RAY CATEGORIES
NORMAL
INCREASED LINEAR STRIATION
EARLY RETICULATION
RETICULATION
RETICULO-NODULATION
NODULATION
MASSIVE SHADOWS

SCATTER DIAGRAM IV [FETTLING SHOP]
CHEST EXPANSION AND X-RAY APPEARANCES



lung They would however be exposed to the dust in the general atmosphere of the shop and might inhale some free silica dust

Diagrams III and IV both show the variation in chest expansion in relation to X ray changes but on the whole the chest expansion tends to be less as the abnormal shadows become more marked

(v) PHYSICAL SIGNS

Physical examination of the chest was made in 179 cases at Factory M and of these 4 were not X rayed There were therefore 175 cases in which the results of physical and X ray examinations can be compared The findings on physical examination fell into 4 main groups —

1 No abnormal physical signs

2 Breath sounds distant or absent no other abnormal signs

3 Breath sounds distant associated with persistent post tussic crepitations (usually over the lower lung fields)

[illegible]

hilar shadows

1 *No abnormal physical signs* No abnormal physical signs were found in 62 cases – 36 moulding shop and 26 fettling shop workers The X ray diagnosis in these cases were as follows —

Normal	43 cases
Early Reticulation	11 cases
Reticulation	8 cases

In 43 cases (69 3 per cent) the findings of the physical and X ray examinations were consistent In 19 cases (30 6 per cent) there were no abnormal physical signs, but some abnormal shadows were seen in the X ray films Early reticulation in this group occurred in 4 moulders 1 sandmixer, 3 fettlers 1 sandblaster, 1 grinder and 1 fitter Reticulation was seen in the X ray films of 2 moulders, 1 bricklayer s labourer 3 fettlers 1 welder and 1 oxyacetylene burner It is obvious therefore that a man can have an X ray picture of early reticulation or reticulation and yet present no abnormal signs on physical examination of the chest

2 *Breath sounds distant or absent but no other abnormal physical signs* Distant or absent breath sounds was the chief feature on the physical examination of 58 cases – 37 moulding shop and 21 fettling shop workers The X ray diagnoses were —

Normal	33 cases
Early reticulation	8 cases
Reticulation	14 cases
Nodulation	1 case
Atelectasis	1 case
Bronchiectasis	1 case

[illegible]

CHAPTER V

PATHOLOGICAL INVESTIGATIONS

BY H E HARDING, S ROODHOUSE GLOYNE AND A I G McLAUGHLIN

One iron fettler from another foundry on the general list has been examined. Similar pathological studies have been made in eight cases from the steel foun-

I FETTLERS OF STEEL CASTINGS

(1) Male. Age 61 years.

History of illness He had attended the Tuberculosis Dispensary in June

Histological sections Tuberculosis in various stages of evolution, some fibrotic areas present, minimal dust reticulation at usual sites, a few discrete nodules of silicosis

Chemical analysis Ash 8 per cent of dry weight

Total Silica 1 7 per cent of dry weight

Comment Massive silicosis with minimal dust reticulation, accompanied by tuberculosis

(2) Male Age 43 years.

Occupational history Steel fettler for 29 years Left school at 14 years of age Two months heating bolts Then to Factory P as a steel dresser where he dealt with castings of 1 cwt to 2 tons with pneumatic hammers For the last 2 years he wore a Mark IV respirator During the last 5 - 6 years the castings had been blasted before fettling Previously not shot or sand blasted.

Family history Nothing relevant No Tb in family

Previous illnesses No serious illnesses since childhood 1926—Steel foreign body in right eye, which was enucleated 1934—Bronchitis, off work for one week

dation and cavitation of the right upper lobe and bronchitic signs over the rest of the lungs. He died 25 11 44

X-ray examination Chest radiograph 3 9.43 showed extensive opacities right lung with large cavity extreme apex Right base clear. Coarse reticulation left lung

(3) Male. Age 51 years.

Occupational History Employed for 32 years as a steel dresser using pneu- ... No other occupation ... in 1942 silicosis was ... ut 2 years before death ... rsistently over 180 mm ... l in hospital the same evening

... voluminous, ... dematous but ... No evidence ... ontracted and ... blood having penetrated to right lateral ventricle

Histological sections (Figs 20 – 26) No tuberculosis ; very marked dust ...

cent of dry weight

Comment Nodular silicosis Death from cerebral haemorrhage and chronic nephritis

(4) Male Age 55 years

lungs, together with emphysema ...

Histological sections (Figs 27 and 28) A few very small giant cell systems of tuberculosis; minimal dust reticulation at usual sites, no silicosis seen.

Chemical analysis Ash 5 per cent of dry weight Total Silica 0 81 per cent of dry weight. Fe_2O_3· 1 76 per cent of dry weight.

no part in his death from coronary thrombosis

(5) Male. Age 64 years.

Occupational history Left school at 11 years of age Worsted mill – 2 years, apprentice, boiler trade – 8 years, army 5 years, boiler riveter – 16 years,

On examination Signs of consolidation and cavitation right upper lobe Sputum contained tubercle bacilli

X-ray examination Scoliosis, diaphragm clear, conglomerate shadows right upper and left midzones, cavitation right upper – some reticulation and nodulation in remainder of lung fields

Gross morbid anatomy Rather bulky lungs showing old fibrous thickening of pleura, very extensive tuberculosis with acute cavitation in right upper lobe and tuberculous broncho-pneumonia in lower lobe, old peribronchial fibrosis in right lung most marked near hilum of upper lobe, lungs marbled with numerous solid firm areas, mainly obviously tuberculous, but some looking purely silicotic

Histological sections (Figs 29 and 30) Tuberculosis, chiefly caseous, minimal dust reticulation at usual sites numerous discrete and conglomerate nodules of silicosis

Chemical analysis Ash 5 17 per cent of dry weight Total Silica 1 41 per cent of dry weight Free Silica 1 22 per cent of dry weight

Comment Nodular silicosis accompanied by tuberculosis, the latter being the predominant feature both radiographically and pathologically

(6) Male Age 62 years.

Occupational history Left school at 14 years of age Errand boy – 1 year, concrete works 2 years, army 6 years, fettler of steel castings – 36 years, as follows —

History of illness Gave up work 14 10 44 Had complained of cough, sputum, shortness of breath for 2 months before being seen by members of the Silicosis Medical Board 3 11 44 On examination found to have silicosis and tuberculosis No tubercle bacilli found in the two specimens of sputum examined Died 5 7 46

X-ray examination 10 10 44 Generalised nodulation and massive shadows suggesting the presence of silicosis and tuberculosis

Gross morbid anatomy Slight general fibrous thickening of pleura with some dense patches, lungs fairly bulky showing generalised tuberculous broncho pneumonia with cavity at right apex, and numerous rounded or oval, hard, marbled black grey nodules up to 1/3 inch in diameter, especially in upper portions of lungs (many of these showed tuberculosis, but many looked purely silicotic)

Histological sections Tuberculosis, chiefly caseous, moderate degree of dust reticulation at usual sites, numerous conglomerate nodules of silicosis

Chemical analysis Ash 4 30 per cent of dry weight Fe_2O_3 0 99 per cent of dry weight Total Silica 0 27 per cent of dry weight Free Silica 0 10 per

ued by tuberculosis with terminal

(7) Male Age 51 years

Occupational history Steel fettler 27 years – both hand and pneumatic tools Left school at 14 years of age Electrician in steel foundry – 8 months, bobbin winder in wire rope mill – 2 years fettler of steel castings (used only hand hammer and chisel) – 17 years fettler of steel castings (pneumatic hammer) – 10 years

History of illness One year before examination by Silicosis Medical Board 8 8 37 had "influenza" and was off work 3 weeks Ceased work 22 6 39 on account of chest symptoms Two months before developed a cough sputum and marked dyspnoea Also had haemoptysis at this time and felt very weak Admitted to sanatorium Sputum – T B + Chest 34½" after deep inspiration 32¾" after deep expiration Died 5 6 46

X ray exam 16 12 37
lung fields
Apices clear

Gross morbid anatomy Greatly thickened pleura over right lung especially the upper lobe

of tuberculosis scattered throughout left lung Both lungs show numerous marbled hard nodules of silicosis up to 1/3 of an inch in diameter, best seen in the left lung

Histological sections (Fig 31) Extensive caseous tuberculosis, fairly well marked dust reticulation numerous discrete and conglomerate nodules of silicosis

Chemical analysis Ash 4 24 per cent of dry weight Fe_2O_3 0 34 per cent of dry weight Total Silica 0 37 per cent of dry weight

Comment Nodular silicosis accompanied by tuberculosis with miliary and pneumonic dissemination

(8) Male Age 64 years

Occupational history Steel fettler at Factory M for 22½ years – pneumatic tools Left school at 14 years of age Butcher – 6 years, casual labourer (gardening etc) – 15 years army 3½ years Then to steel foundry as steel fettler 22½ years

History of illness In 1942 developed pains in the chest and dyspnoea with slight cough and expectoration These symptoms gradually got worse and he gave up work in September 1942 A diagnosis of silicosis was made by the Silicosis Medical Board This man was examined during the general survey of foundry workers (Factory M) on 22 3 44 He complained of shortness of breath even at rest, and severe pains in the chest

X-ray examination Diaphragmatic outlines blurred and peaked Heart shadow blurred and aortic shadow broadened Emphysema both bases Massive shadows and nodulation both lung fields apices fairly clear. He died 23 4 46, but unfortunately we did not hear of his death until some months later

Gross morbid anatomy The only notes obtainable of the autopsy were "Lungs small – widespread pleural thickening with considerable diffuse infiltration in the upper parts and scattered nodules of silicosis Commencing necrosis in apex of right lung " No mention is made of the presence or absence of tuberculosis

Comment Nodular silicosis Inadequate autopsy record

(9) Male Age 46 years.

Occupational history Fettler of steel castings for the same Sheffield firm for 20 years – pneumatic tools No other occupation

History of illness Given certificate for partial disablement from silicosis by Silicosis Medical Board in 1937, 10 years before his death Had done no fettling since then Died 4 2 47

considerable pigment, emphysema broncho pneumonia, no tuberculosis Incinerated sections show only a moderate amount of iron around the nodules

Chemical analysis Ash 3 95 per cent dry weight Total SiO_2 0 78 per cent dry weight Free SiO_2 0 32 per cent dry weight Fe_2O_3 0 40 per cent dry weight

Comment Massive silicosis with emphysema and terminal bronchopneumonia

(10) Male. Age 52 years.

Occupational history Steel fettler 28½ years pneumatic tools Left school at 16 years of age Steel fettler, Sheffield – 5 years, steel fettler, Leeds – 1½ years, steel fettler, Sheffield – 8 years, steel fettler, Scunthorpe – 2 years, coal miner, Orgreave 7 years, unemployed 2 years, steel fettler, Sheffield – 7 years, away from work ill 3½ years, steel fettler, Sheffield – 5 years, off work ill (up to date of death) – 1 year

History of illness. About nine years before his death he began to suffer with chest trouble and to lose weight At the Tuberculosis Dispensary he was found to have silicosis and tuberculosis Tubercle bacilli were found in the sputum

Gross morbid anatomy Autopsy 9 12 43 showed that the body was fairly well nourished, both lungs were firmly adherent to the chest wall, massive silicosis was present in both lungs, the bases of both lungs were oedematous, the lungs were black and black liquid was present in cavities, the heart weighed 16 ounces, the enlargement being due mainly to marked hypertrophy of the right ventricle which was also dilated Apart from congestion and changes due

in this case

Comment Massive silicosis accompanied by tuberculosis Congestive heart failure

of age On 11 4 42 was seen by Silicosis Medical Board and he was certified as totally disabled by silicosis No tubercle bacilli found in sputum Died in hospital 22 7 46 from peritonitis following an operation for acute appendicitis

X ray examination Nodulation of both lung fields

Gross morbid anatomy Very marked emphysema with bullae up to 3" diameter massive silicotic fibrosis both upper lobes, scattered hard nodules throughout, greatly pigmented lungs, very large silicotic hilar glands no evident tuberculosis peritonitis following gangrenous appendicitis.

Histological sections No tuberculosis, well marked dust reticulation at usual sites, many discrete and conglomerate nodules of silicosis

Chemical analysis Ash 6 48 per cent of dry weight Total silica 1 8 per cent of dry weight Free silica 1 0 per cent of dry weight Fe_2O_3 1 3 per cent of dry weight

Comment Massive silicosis and emphysema Death from acute appendicitis and general peritonitis

(16) Male Age 40 years.

Occupational history Steel dresser 23 years at Factory P No other details available

History of illness Not available Died 24 3 41

Gross morbid anatomy Lungs adherent to chest wall, large tuberculous cavity in right upper lobe massive silicosis in left lung broncho-pneumonia at both bases adherent pericardium

Histological sections Discrete and conglomerate silicotic nodules, areas of ... aining tubercle bacilli and giant cells,

... panied by tuberculosis with broncho

(17) Male Age 60 years

... of age

... of ... type in both lungs interstitial fibros ...

... ogether with

... tuberculosis

(18) Male Age 30 years

Occupational history Steel dresser at Foundry P for 10 years. Good record of attendance Previously worked in timber yard on saw mill No other jobs ... 1944 d ... ring an investigation ... *had no symptoms* ... clear P 78 B P ... physical

X ray examination ... howed generalised reticulation with large root shadows and a massive shadow in left mid zone

FIG. 70 SILICOTIC NODULES WITH EARLY CENTRAL NECROSIS LOCAL EMPHYSEMA X5 Case 3 Chap V

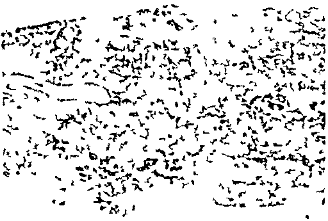


FIG. 71 SILICOTIC NODULES WITH EARLY CENTRAL NECROSIS LOCAL EMPHYSEMA X5 Case 3 Chap V

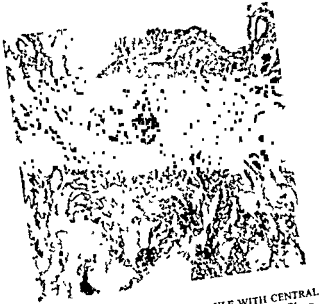


FIG 22 PERIBRONCHIAL NODULE WITH CENTRAL NECROSIS (NON-TUBERCULOUS) X23 Case 3, Chap V.

FIG 23 AREA OF PERIVASCULAR AND PERIBRONCHIAL FIBROSIS X50 Case 3, Chap V

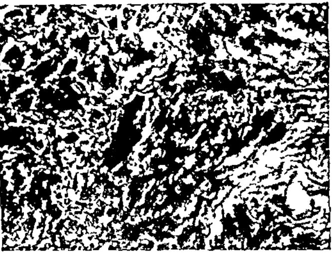


FIG 24 RETICULIN FIBROSIS AND DUST PARTICLES
X500 Case 3 Chap V

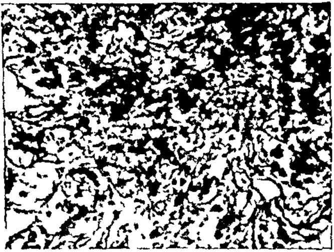


FIG 25 EARLIER STAGE OF PROCESS SEEN IN FIG 24
X500 Case 3 Chap V

FIG. 26 RETICULIN AND COLLAGEN FIBRES OCCURRING TOGETHER IN SAME AREA OF FIBROSIS X500 Case 3, Chap. V.

FIG 27. MIXED DUST PNEUMOCONIOSIS: EMPHYSEMA: OEDEMA X5. Case 4, Chap. V.

FIG 28 M XED DUST PNEUMOCONIOSIS NODULES EMPHYSEMA OEDEMA X1? Case 4 Chap V

FIG 29 MASSIVE SILICO-TUBERCULOSIS X5 Case 5 Chap V

FIG 30 MASSIVE SILICO TUBERCULOSIS
X5 Case 5 Chap V

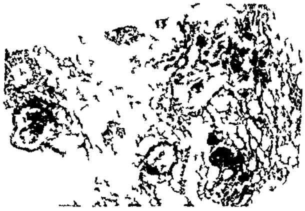


FIG 31 SILICOTIC AND MIXED SILICO TUBERCULOUS
NODULES EMPHYSEMA X5 Case 7 Chap V

FIG 32 SILICOSIS EMPHYSEMA X5 Case 9 Chap V

FIG 33 MASSIVE SILICOSIS X5 Case 11 Chap V

FIG 34 MASSIVE SILICOSIS PLEURAL THICKENING
X5 Case 13 Chap V

FIG 35 EARLY SILICOTIC NODULATION
X10 Case 22 Chap V

Gross morbi...

...*ological sections* Lungs showed tuberculosis in various stages of evolution, prussian blue halo around some of the dust particles, small conglomerate nodules of silicosis and some caseous tuber...

Comment ...
noted in ...

(19) Male. Age 60 years.

Occupational history Left school at 13 years of age, bolt making 2 years, driller of iron girders 10 years army service 2 years, unemployed 1 year, machining bolts (iron) 3 years, then worked at steel foundry (P) for 30 years as a steel fettler (hand hammer 10 years, emery wheel and pneumatic tools 20 years)

...rements 33" 34" 32½" expansion
... 96 Spirometry 1100, 2850, 2400
...
...ces breath sounds distant all over
with tendency to aegophony in right hil...
Other systems normal

X ray examination (1945) (See Plate V) Both lung fields show fine generalised reticulo-nodulation with conglomerate shadows in right mid zone and right and left supraclavicular regions A few discrete nodules in both upper lateral regions A provisional diagnosis of silico tuberculosis made

Autopsy Death due to silicosis and advanced tuberculosis No further details

Histological sections Tuberculosis of all ages terminal purulent inflammation a few silico-tuberculous nodules but no purely silicotic ones found (section taken from anterior margin of lung which was least affected), dust reticulation slight practically no iron in incinerated sections

Chemical analysis Ash 2·04 per cent of dry weight Total silica 0·27 per cent of dry weight Free silica 0·22 per cent of dry weight Fe_2O_3 0·44 per cent of dry weight

Comment Extensive pulmonary tuberculosis with silico-tuberculous nodules slight dust reticulation

(20) Male Age 43 years

Occupational history Steel fettler 22 years. Left school at 14 years of age and worked in the same steel foundry as a fettler of steel castings (pneumatic hammer) from 1915 1937 For about a year he worked as a welder

History of illness He suffered from recurrent chest illnesses since 1927 in 1933 he was away from work for 3 months and in April 1937 for one month His doctor made a provisional diagnosis of silicosis in 1928 He died on 4 12 37

Gross morbid anatomy There were dense pleural adhesions over the left lung posteriorly and less dense adhesions over both lungs generally The lungs were emphysematous and overlapped the heart, series of cavities in the posterior part of the left upper lobe, the walls of the cavities contained no caseous

(21) Male. Age 67 years

Occupational history Fettler of steel castings in one firm for 32 years Began work about 1890 *as an apprentice steel dresser and worked at the trade until* 1921

History of illness In 1921 he became ill was diagnosed as having silicosis and was away from work for 2 years He returned to work again for a few months and had to give up finally in *1924 He* died in hospital from silicosis and bronchitis in January 1942

Gross morbid anatomy No record of autopsy Both lungs received, showing massive silicosis in upper lobes and nodules in lower

Histological sections Massive conglomerate silicotic nodulation, extensive dust reticulation and some focal emphysema

Comment Massive silicosis and extensive dust reticulation with some focal emphysema

I(a) WELDER IN STEEL FETTLING SHOP

(22) Male Age 55 years Carbon arc welder 34½ years

Occupational history Started work at 19 years of age in 1911 as a labourer in a fettling shop of a steel foundry After 6 months he was transferred to grinding steel castings on a swing frame grinder for *about a year*

'Ie worked for

" shops where

was adhering

d night shifts

8 – 9 years

right

expansion very poor percussion note impaired both bases reased tactile fremitus at bases slightly prolonged respiratory murmur breath sounds harsh occasional rhonchi râles both bases *Liver and spleen not palpable* through oedematous abdominal wall no shifting *dullness His* urine contained numerous

pus and epithelial cells moderate numbers of granular, hyaline and waxy casts, scanty red cells Hb 100 per cent red cells 4,980,000, white cells 10,000 He died 7 2 47

X-ray examination (See Plates VI and VII) Film, which was taken with a portable machine is not entirely satisfactory, but is reproduced here Diaphragms normal effusion at right base and nodular shadows in both lung fields probably also an effusion at left base An area of discrete mottling in right mid-zone

Gross morbid anatomy Lungs did not collapse on opening chest, about 5 oz. clear fluid right pleural cavity Dense adhesions at each base, more marked on the left side Both lungs congested and emphysematous particularly at margins where there were many large bullae, bases of each lung friable, sections from right lung sank in water No subpleural nodules In mid-zone of right

Bronchi contained blood stained mucus, otherwise normal Pulmonary arteries dilated

Heart markedly enlarged (450 G) marked dilatation and hypertrophy right auricle and right ventricle Pulmonary artery dilated with mild atheromatous change at its bifurcation Mitral cusps and chordae tendiniae thickened with row of hard nodules on valve leaf Left ventricle much hypertrophied but not dilated

Liver enlarged, fatty, swollen, some cirrhosis Venous congestion of spleen Kidneys 240 gm, capsules adherent, slightly granular surfaces congested, cortex not thinned good differentiation increased perinephric fat

Histological sections Lungs – some emphysema, patchy haemorrhages, some of them old Acute bronchitis, early broncho-pneumonia Much pigment of two kinds, brown and black, within phagocytes the former gives the Prussian blue reaction for iron, the latter remains black More black than

Chemical analysis Ash 14.20 per cent of dry weight. Total silica. 0 28 per cent of dry weight Free silica 0 11 per cent of dry weight Fe_2O_3 10 47 per cent of dry weight

Comment Early nodular silicosis with siderosis, emphysema, and congestive failure A fairly full report has been made in this case because it suggests

remarkably high an indeterminable proportion of the iron was haematogenous.

II FETTLERS AND GRINDERS OF IRON CASTINGS

(23) Male Age 51 years

Occupational history Hand fettler of iron castings in one firm (Factory G) all his working life (36 years) had never used pneumatic tools

a month
two long
1942 to
hest was
liagnosis
4
a back
ground of fine reticulation and also areas of more intense shadowing in the right lower zone and over the upper two thirds of the left lung In the th rd intercostal space may be seen an annular shadow suggesting the presence of a
er zone Large
Another

nount of
fluid in the right Both lungs dark with much venous engorgement *In*
Throughout the
is a large ragged
lymph nodes at
te obliteration of
art
nodules old and
recent pleurisy present lungs markedly pigmented with much cavitation in the left upper lobe and extensive tuberculous broncho pneumonia in both lungs especially in the upper lobes some fine emphysema silicosis doubtful

Histological sections (Fig 36) Tuberculosis chiefly caseous moderate degree of dust reticulation a few discrete nodules of silicosis *The following* note was made by one of us after seeing the sections in *1944* *They show* tuberculosis in many parts of the lungs but in other parts there are *patches of* fibrosis not typical of either tuberculosis or silicosis It may be that these areas are silicotic fibrosis modified by admixture of du ts other than free silica

Chemical analysis Ash 7 1 per cent of dry weight Total silica *1 3*5 per cent of dry weight Fe_2O_3 2 0 per cent of dry weight

her w th atyp cal
sil ca
han of
tuberculosis and the indefinite shadows sugge station
were missed by all observers until autopsy revealed the presence of tuber culosis *It is clear that the tuberculosis was limited in area when the* X ray film was taken and that it had spread considerably in the six months wh ch elapsed before the man s death

(24) Male Age 46 years

n a foundry

History of illness He had been in good health up to December 1938 when he began to suffer from pains in the chest, dyspnoea, and a cough with black [illegible] returned [illegible] He had [illegible] ber 1939 [illegible] gnosis of [illegible]

X-ray examination 20 12 39 Fine reticulo-nodulation over both lung fields with ground-glass background Both diaphragms blurred and shadows more concentrated over lower lobes Some massive shadows at base (? patches of broncho pneumonia)

Gross morbid anatomy There were old adhesions in the lower part of the right pleural cavity between the lung, chest wall and diaphragm The surfaces of both lungs, particularly in the upper lobes, were gritty to the touch In addition several small hard nodules about 1 cm in diameter, could be felt in the substance of the lungs Emphysema was present over the apices of both lungs The lower lobe of each lung was consolidated and small pieces sank in water On section a similar gritty consistency was noted The bronchial glands were enlarged and were darkly pigmented The heart was slightly enlarged but no valvular disease was found In the abdominal cavity *lymphatic glands in the region of the lesser curvature of the stomach* were slightly enlarged and darkly pigmented The spleen was slightly enlarged but of normal consistency The kidneys were congested the other organs were normal for his age Death was due to bilateral broncho-pneumonia supervening on pneumoconiosis of the lungs

Histological sections (Figs 37 39) Marked black pigmentation, most of the pigment being in irregularly shaped aggregates of phagocytes included in collagenous fibrous tissue, around and alongside pulmonary vessels and in alveolar walls No definite silicotic nodulation but at least one pigmented area shows fibrosis which is tending to become circular rather than remain radial Incinerated sections show that most of the black pigment is iron Other parts of the sections show the presence of a patchy purulent pneumonia

Comment Marked pneumoconiosis of dust reticulation type, emphysema and purulent pneumonia In a paper by Dunner, L, Hermon, R, and Bagnall, D J T in Brit J Radiol, 1945 *18* 37 a description was given of the results of radiographic examinations of dressers of iron castings in the same factory Chemical analyses of the dust are also given

(25) Male. Age 55 years Grinder of iron castings

Occupational history Left school at 13 years of age and from then worked as a grinder of iron castings (with emery wheels) in one iron foundry in the Midlands for 36 years No other occupation

History of illness Gave up work in 1940 on account of ill health Tubercle bacilli said to have been present in the sputum Ill at home for 10 months before his death on 11 1 46

Autopsy Wasted, clubbing of fingers and toes Lungs – pleurae densely adherent, oedematous greenish black massive fibrosis both upper halves of lungs, numerous cavities Mediastinal glands enlarged and hard Heart – right sided dilatation muscle brown, coronary arteries and valves healthy

Histological sections Show (i) well marked conglomerate silicotic nodules (ii) squamous carcinoma and (iii) some necrotic areas showing a few typical tuberculous giant cells but no tubercle bacilli

Comment Massive silicosis accompanied by tuberculosis Squamous cell carcinoma also present

(26) Male. Age 54 years Fettler of iron castings at one foundry for 40 years

Occupational history Left school at 14 years and went as fettler of iron castings to an iron foundry where he continued all his working life

History of illness Pneumonia at 40 years of age Tubercle bacilli found in *sputum in 1946 Died 10 11 46*

Gross morbid anatomy Well marked nodular silicosis with aggregations up to ¾ inch in diameter, bronchiectasis, *terminal pneumonia, no definite* tuberculosis on naked eye examination

Histological sections Marked tuberculo silicosis, much iron pigment both in alveoli and connective tissue

Chemical analysis Ash 6 22 per cent of dry weight Total silica 1 58 per cent of dry weight *Free silica* 0 67 per cent of dry weight Fe_2O_3 1 56 per cent of dry weight

Comment Nodular silicosis accompanied by tuberculosis

(27) Male. Age 50 years. *Fettler (barreller) of malleable iron* castings 31 years

Occupational history From 1909 – 1936 (except war service 1914 – 1919) [illegible] From 1936 – 1945 worked

Autopsy Acute pericarditis with much deposition of fibrin and a large effusion, heart generally dilated and hypertrophied, some coronary arterio-sclerosis

Pleurae adherent on both sides, some *effusion Lungs black throughout* with large and small dark rubbery and gritty areas, the upper lobes of both being almost entirely replaced by such areas, some broncho pneumonia present in both lungs Liver, marked chronic venous congestion, spleen enlarged, dark and firm, kidneys congested, capsules stripped well

Histological sections The alveolar tissue is almost entirely replaced by a mass of roughly whorled conglomerate nodules some of which are pigmented others necrotic A section of a hilum gland shows that the lymphoid tissue replaced by nodules resembling those in the lung These resemble *the mixe* dust nodules seen in coal miners Other sections from lung show also per bronchial and perivascular fibrosis with pigment like that of a dust reticulation

Comment Nodular silicosis with congestive failure and terminal broncho pneumonia

(28) Male Age 44 years. Iron dresser at a firm in the Midlands

Gross morbid anatomy Lungs massive and solid, both showed extensive diffuse soft fibrosis of nodular type All bronchi were dilated, but not saccular The fibrosis was interspersed with numerous small excavations probably tuberculous but possibly bronchiectatic

[illegible] in various stages

Comment Nodular silicosis accompanied by tuberculosis

(29) Male. Age 61 years. Iron dresser for 34 years at firm in Midlands

History of Illness. Had not worked for 10 years owing to chronic chest trouble. Became acutely ill 23 3 39 and died 10 days later. No records of clinical or X-ray examination

Gross morbid anatomy Voluminous lungs of hypertrophic emphysema, left lung adherent to chest wall, right practically free Both deeply pigmented and showed patches of acute pleurisy On section, lungs are deeply pigmented, rather tough and oedematous with pus in the main air passages Scattered tiny areas of broncho-pneumonia No conclusive evidence of silicosis or tuberculosis Heart muscle flabby Nothing noteworthy in other organs

Histological sections Marked perivascular and peribronchial fibrosis with much black pigment, emphysema present, no tuberculosis seen A few small non-whorled nodules of dust reticulation type found

Comment Minimal dust reticulation with chronic bronchitis and emphysema Death from acute broncho pneumonia

(30) Male Age 46 years.

[illegible] on trimmer smoothing iron castings [illegible] 1922 to 1936 Left this work owing [illegible] ...rculosis) and did various odd jobs until he finally broke down

History of Illness Went to a sanatorium for a period during 1935 Admitted to hospital on 6 2 1946 and died 10 8 1946

Gross morbid anatomy Slight clubbing of fingers and toes Small abscess containing ½ oz pus in 5th left intercostal space Pleurae adherent at both apices. Extensive emphysema Tuberculous cavities at apex and base of right upper lobe Silicotic nodules widely distributed confluent mass in right upper lobe Extensive caries of 5th and 6th dorsal vertebrae with abscess containing ½ oz. pus behind anterior common ligament

Histological sections Discrete and conglomerate nodules of silicosis and tuberculosis tuberculosis in various stages of evolution from caseous foci and areas of broncho-pneumonia to fibrotic nodules

Comment Massive silicosis with emphysema accompanied by pulmonary tuberculosis and haematogenous dissemination to vertebral column

III STEEL MOULDERS

(31) Male Age 56 years. Steel moulder's labourer

Occupational history Had been engaged as a moulder's labourer in a steel works for 3 years previously he had worked as a corporation labourer in the sewers department No other details available

History of illness Hypertension for 16 years In hospital in 1942 with cardiac enlargement (B P 150/110) Severe dyspnoea on exertion 3 years, orthopnoea, cough, [illegible]
1 2 47 w [illegible]
Pulse 90 [illegible]
albumin [illegible]
(80 per c [illegible]
Cheyne-Stokes respiration, and died 15 2 47

Autopsy Marked oedema No pleural effusions Gross hypertrophy of left ventricle, dilated left auricle Dilatation and hypertrophy right ventricle Coronary

Gross morbid anatomy after fixation Marked generalised emphysema Only moderate amount of black pigment in scattered aggregates no definitely palpable nodules

onchiectatic

Slight but

Chemical analysis Ash 2 90 per cent of dry weight Total SiO_2 0 28 per cent of dry weight Free SiO_2 0 22 per cent of dry weight Fe_2O_3 0 70 per cent of dry weight

Comment Minimal fibrosis of dust reticulation type accompanied by emphysema and chronic bronchitis Death from broncho pneumonia, and myocardial failure from hypertension

IV IRON MOULDERS

(32) **Male** Age 52 years Iron moulder 32 years

Occupational history Employed as an iron moulder at one iron foundry for 32 years, since he was 16 years of age

Gross morbid anatomy (Autopsy 2 1 45) Thick muco pus in the trachea and large bronchi and reddening of the mucous membrane Early acute pleurisy over right upper and middle lobes some old adhesions across front of right lung Right upper lobe uniformly solid, mottled grey exuding pus The right middle lobe was partly involved in a similar pneumonia, lower lobe congested The left lung showed marked emphysema at the apex the whole lung very congested and oedematous Some pigmentation but no fibrosis visible naked eye Tracheo bronchial glands pigmented and oedematous, mottled blue grey Dilatation of right side of heart, valves normal Petechial brain Cloudy swelling of the , chronic venous congestion of rmal The cause of death was lobar pneumonia

Histological sections Slight to moderate degree of emphysema of the left lung, congestion and oedema of the lower lobes Pigment in alveolar phagocytes and in small aggregat to fibrosis in relation to pigmer no whorled lesions aggregates is iron

Chemical analysis Ash 2 67 per cent of dry weight Fe_2O_3 0 40 per cent of dry weight Total silica 0 4 per cent of dry weight

Comment Minimal fibrosis of dust reticulation type accompanied by emphysema Death from lobar pneumonia

(33) Male Age 60 years Iron moulder 30 years

Occupational history Employed as an iron moulder in a Sheffield iron foundry for over 30 years Died Dec 1944

Gross morbid anatomy Cachexia carcinoma of the stomach producing obstruction 2 inches from the pylorus Lungs congestion and broncho pneumonia of both lungs pleural adhesions both sides slight emphysema some pigmentation in aggregates but no obvious fibrosis on naked-eye examination After fixation the pleura showed notable blue marbling the pigmented areas in the lungs were more emphysematous than the rest of the lungs There was no solidity to any pigmented area

Chemical analysis Ash 4 81 per cent of dry weight Fe_2O_3 0 99 per cent of dry weight Total silica 1 39 per cent of dry weight

Comment Minimal fibrosis of dust reticulation type with focal emphysema Death from broncho pneumonia and cancer of the stomach producing obstruction of the pylorus

(34) Male Age 54 years Iron moulder 24 years

Occupational history Worked as iron moulder at a foundry from 1920–1944 Before 1920 he did farm labouring and was in the army between 1915 and 1919 Up to 1939 silica parting powders were used in the foundry

History of illness For 2½ years before his death he had suffered from 'asthma and bronchitis' Admitted to hospital on 1 10 46 and died the next day No X ray examination

Gross morbid anatomy Small lungs Black marbled pleura the marbling not being raised or palpable Marked emphysema mainly fine Black nodules in lung not palpable or doubtfully so No evident tuberculosis

Histological sections Marked pigment reticulation Small silicotic nodule near root of lung and some silicotic nodules in lymph gland Bronchiectasis emphysema After incineration some areas show considerable amounts of iron other areas only a little

Chemical analysis Ash 4 90 per cent of dry weight Total silica 0 89 per cent of dry weight Free silica 0 57 per cent of dry weight Fe_2O_3 0 73 per cent of dry weight

Comment Slight nodular silicosis with marked dust reticulation accompanied by emphysema and bronchiectasis

The following three cases 35 36 and 37 all came from the same iron foundry (Factory K) and a full clinical and radiological examination was made of the other moulders in the foundry (see p 133)

Gross morbid anatomy after fixation Marked generalised emphysema Only moderate amount of black pigment in scattered aggregates no definitely palpable nodules

Histological sections Emphysema, broncho pneumonia bronchiectatic abscesses Moderate amount of pigment much of it still in alveoli Slight but definite "dust reticulation"

Chemical analysis Ash 2 90 per cent of dry weight Total SiO_2 0 28 per cent of dry weight Free SiO_2 0 22 per cent of dry weight Fe_2O_3 0 70 per cent of dry weight

Comment Minimal fibrosis of dust reticulation type accompanied by emphysema and chronic bronchitis Death from broncho pneumonia, and myocardial failure from hypertension

IV IRON MOULDERS

(32) Male Age 52 years Iron moulder 32 years

Occupational history Employed as an iron moulder at one iron foundry for 32 years since he was 16 years of age

History of illness H... for some years but did not give ... pains in the chest and ... for the previous week ... film was taken of his chest Died 1 1 45

Gross morbid anatomy (Autopsy 2 1 45) Thick muco pus in the trachea and large bronchi and reddening of the mucous membrane Early acute ... adhesions across front ... mottled grey exuding pus ... pneumonia, lower lobe congested The left lung showed marked emphysema at the apex, the whole lung very congested and oedematous Some pigmentation but no fibrosis visible naked eye Tracheo bronchial glands pigmented and oedematous, mottled blue grey Dilatation of right side of heart, valves normal Petechial haemorrhages throughout the substance of the brain Cloudy swelling of the kidneys, small, toxic spleen, pancreas normal, chronic venous congestion of the liver, bladder, stomach and intestines normal The cause of death was lobar pneumonia

Histological sections Slight to moderate degree of emphysema of the left lung, congestion and oedema of the lower lobes Pigment in alveolar phagocytes ... some tendency to fibrosis ... or radial and there are ... of the pigment in the ... aggregates is iron

Chemical analysis Ash 2 67 per cent of dry weight Fe_2O_3 0 40 per cent of dry weight Total silica 0 4 per cent of dry weight

Comment Minimal fibrosis of dust reticulation type accompanied by emphysema Death from lobar pneumonia

(33) Male. Age 60 years. Iron moulder 30 years

Occupational history Employed as an iron moulder in a Sheffield iron foundry for over 30 years Died Dec 1944

Gross morbid anatomy Cachexia, carcinoma of the stomach producing

in the lungs were more emphysematous than the rest of the lungs There was no solidity to any pigmented area

nly in the upper lobes, many
ia present in the lower lobe
varying age, the older showing
definite collagenous fibrosis, no whorled formations seen

Chemical analysis Ash 4 81 per cent of dry weight Fe_2O_3 0 99 per cent of dry weight Total silica 1 39 per cent of dry weight

Comment Minimal fibrosis of dust reticulation type with focal emphysema Death from broncho-pneumonia, and cancer of the stomach producing obstruction of the pylorus

(34) Male. Age 54 years. Iron moulder 24 years

Occupational history Worked as iron moulder at a foundry from 1920–1944 Before 1920 he did farm labouring and was in the army between 1915 and 1919 Up to 1939 silica parting powders were used in the foundry

History of illness For 2½ years before his death he had suffered from "asthma and bronchitis" Admitted to hospital on 1 10 46 and died the next day No X ray examination

Gross morbid anatomy Small lungs Black marbled pleura, the marbling not being raised or palpable *Marked emphysema, mainly fine Black nodules* in lung not palpable or doubtfully so No evident tuberculosis

Histological sections Marked "pigment reticulation" Small silicotic nodule near root of lung and some silicotic nodules in lymph gland Bronchiectasis, emphysema After incineration some areas show considerable amounts of iron, other areas only a little

Chemical analysis Ash 4 90 per cent of dry weight Total silica 0 89 per cent of dry weight Free silica 0 57 per cent of dry weight Fe_2O_3 0 73 per cent of dry weight

Comment Slight nodular silicosis with marked dust reticulation accompanied by emphysema and bronchiectasis

The following three cases, 35, 36 and 37, all came from the same iron foundry (Factory K) and a full clinical and radiological examination was made of the other moulders in the foundry (see p 133)

(35) Male. Age 32 years.

Occupational history Iron moulder 13 years Left school at 14 years of age; for three years (14 to 17) worked in a coal pit, for the next 13 years until 1942, worked as a moulder in an iron foundry He left work on the 16th July on account of chest trouble Died July 1943

X ray examination Extensive nodulation over both lung fields

Gross morbid anatomy Scattered tiny grey-black nodules, nearly all soft In one area there is a subpleural nodule ½ inch in diameter which is rather hard but not as hard as a typical silicotic nodule Inflammatory scarring and some pinhead white nodules at one apex Marked bronchiectasis and emphysema at lower lobes of the other lung

Histological sections (Figs 40 and 41) Bronchiectasis, no tuberculosis Emphysema and marked silicotic nodulation present

Comment Nodular silicosis accompanied by bronchiectasis This man was working on moulds for very small castings and was exposed to clouds of dust from parting powder while it was being dusted on the moulds many times during a shift

(36) Male. Age 32 years.

Occupational history Iron moulder all his working life (18 years) since leaving school at 14 years of age

before h s death

X-ray examination Films showed widespread nodulation with a ground-glass background The individual nodules were from 5 to 7 mm in diameter

Gross morbid anatomy Lungs, widespread tuberculosis with some small cavities, no naked eye silicotic nodules

Hi tol g cal sections (Fig 42) No nod les seen

bu

e c

a case of silico tuberculosis

given before occupational history was known)

Chemical analysis Ash 4 6 per cent of dry weight Total silica 1 96 per cent of dry weight Free silica 1 05 per cent of dry weight Fe_2O_3 0 43 per cent of dry weight

Comment Silicosis accompanied by tuberculosis (silico tuberculous type of mixed nodule)

(37) Male Age 35 years

for 17 years

History of illness Complained for years that the dust in the foundry made him cough In December 1945 became acutely ill and died on 26 12 45 after a severe haemoptysis

olidation

he lower

discrete

as in the right lung

Histological sections Well marked nodular silicosis, lobar pneumonia no tuberculosis

Chemical analysis Ash 9 01 per cent of dry weight Fe_2O_3 1 86 per cent of dry weight Total silica 3 66 per cent of dry weight Free silica 2 36 per cent of dry weight.

Comment Nodular silicosis Death from lobar pneumonia

(38) Male Age 63 years

Occupational history Since 13 years of age he was employed as an iron moulder by the same firm for about 50 years Dry sand from the sandblast chamber is stated to have been used at one period as a parting powder

History of illness Admitted to hospital as an emergency on 30 6 46 with a peri-urethral abscess and cellulitis Died on 15 7 46 No X ray films taken of the chest while in hospital

tubercle bacilli. Many pleural adhesions especially over left lung the apex of which was firmly adherent to the chest wall On removal of lungs the left apex tore away revealing a large ragged cavity 6 × 5 × 3 cm Dense interlobar adhesions right lung cut surfaces of both lungs showed numerous scattered deeply pigmented fibrous nodules separated by emphysematous lung tissue Except for a portion of the apex and the anterior border the right upper lobe was entirely replaced by a conglomerate mass of silicotic nodules in which fine white strands and circles of fibrous tissue were visible to the naked eye all nodules were of very hard rubbery consistence There were a few small caseous nodules mostly in the left upper lobe Hypertrophy and dilatation of the left ventricle

Histological sections Silicosis of very marked degree with massive con glomerations and scattered nodules Tuberculosis well marked but much less extensive than the silicosis

Chemical analysis Ash 4 0 per cent of dry weight Total silica 1 2 per cent of dry weight Free silica 0 6 per cent of dry weight Fe_2O_3 0 57 per cent of dry weight.

Comment Massive silicosis accompanied by tuberculosis Death from peri urethral abscess and cellulitis probably secondary to tuberculous epididymitis

(39) Male Age 63 years

Occupational history Employed as iron moulder and caster in 3 different iron foundries for 41 years (11 20 and 10 years respectively)

History of illness Developed pulmonary tuberculosis some years before his death and attended the tuberculosis dispensary Died on 29 3 45 from tuber culous broncho pneumonia

resembling coal miner s dust reticulation

Comment Nodular silicosis and dust reticulation accompanied by tuberculosis

V SHOT AND SANDBLASTERS

(40). Male. Age 48 years.

Occupational history Left school at 13 years of age Errand boy for 3 years, timekeeper 4 years, shotblaster 10 years, road navvy 4 years, shotblaster 7 years, Army 2 years 1914-18 war (shrapnel wound of arm and chest), shotblaster at another steel firm 3½ years crane driver at same firm 2 years He had been a shotblaster for 20½ years in all

History of illness On 10 9 42 had an haemoptysis and attended a Tuberculosis Dispensary where X-ray film of chest was taken No T B in sputum admitted to a sanatorium on 2 10 42 Seen by Silicosis Medical Board on 6 11 42 Complained of dyspnoea, cough and sputum On examination he had scar of a gunshot wound in left axillary region Died 8 12 44

X-ray examination Fine stippling and reticulation scattered over both lung fields with a woolly, ground glass shadow in right outer sub-clavicular area. (It is probable that this shadow represented the early carcinoma from which he died 2 years later)

Gross morbid anatomy Post mortem examination revealed a very large cancer in the right lung breaking down in parts with much destruction of lung tissue A septic broncho pneumonia and marked bronchiectasis present in right lower lobe with marked thickening of pleura over this lobe *No sign of* tuberculosis, marked pigmentation of both lungs with a fine nodulation suggesting early silicosis

Histological sections Squamous celled carcinoma and very marked oedema of the lungs No typical silicotic nodulation was present but there was definite collagenous fibrosis of linear and radial type in the areas of pigment aggregation No tuberculosis seen

Comment Death from cancer of the lung and broncho pneumonia Fibrosis

nan s lungs showed
dust control in his

(41). Male. Age 45 years

Occupational history Left school at 13 years of age, farm labourer 5 years, Army, 2 years Then went to a steel firm as a shotblaster (using *shot* and sand) until he gave up work owing to chest trouble, 20 years *From* 1923–1926 owing to slack trade in the steel industry he worked as a labourer on the road, 3 years

History of illness In the latter part of 1940 began to complain of cough, expectoration, dyspnoea and loss of weight no haemoptysis Referred by his doctor to Tuberculosis Dispensary Examined by Silicosis Medical Board on 14 5 41 and found to have silicosis and tuberculosis Sputum T B present Died 15 11 42

X ray examination 14 3 41 Film showed fine reticulo nodulation over both lung fields with coarse nodulation in the upper lateral zones Over the lower part of the right upper lobe is a massive shadow within which are rarefied areas suggesting the presence of two cavities Appearances are consistent with a diagnosis of silicosis and tuberculosis

Gross morbid anatomy (Autopsy 17 11 42.) The body was emaciated The right lung showed extensive cavitation and caseation and there were large cavities in the left lung Both lungs showed a widespread silicosis of a fine type Nothing special about the other organs except that there seemed to be an excess of cerebrospinal fluid due possibly to a terminal inflammation of the meninges

Comment Nodular silicosis accompanied by tuberculosis

(42) Male Age 71 years

Occupational history Foundry labourer for 40 years Last three years a sandblaster s labourer Left school at 14 years of age Grocer s errand boy, 1 year Foundry labourer 12 years sandmixer 1 year moulder s labourer, 4 years core drying stoves ' years engineering shop labourer 5 years Out of work a number of years Had done no fettling or sandblasting His work of sandblaster s labourer consisted of removing shot and sand from the sandblast apparatus into bags and wheeling it out to the tip yard

History of illness Ceased work on 15 10 45 on account of weakness cough, shortness of breath and pain in the chest no haemoptysis Admitted to hospital for observation Sputum negative for T B on six occasions Died 14 2 46

X ray examination Film shows a typical fibrosis with a massive shadow in the right lower lobe

Gross morbid anatomy Extreme emaciation No oedema Right lung adherent to chest wall with greatly thickened pleura especially over the right base Black congested and tough consolidation of the right lower lobe Small new growth in right lower lobe bronchus Some fibrosis present in lung parenchyma Emphysematous bullae at margins of lobes Bronchiectasis Left lung shows fibrosis and consolidation of upper lobe Atheroma of thoracic and abdominal aorta and of coronary arteries myocardial degeneration Liver, spleen and kidneys reduced in size and fibrotic

Histological examination Fibrosis mainly related to bronchiectasis, but definite although slight fibrosis of dust reticulation type present throughout the lungs with a few small silicotic nodules Ill differentiated carcinoma of bronchus No tuberculosis

Comment Early nodular silicosis with emphysema bronchiectasis and bronchial carcinoma

(43) Male Age 35 years

Occupational history Left school at 13 years of age Munition work, 1 year, musical instrument repairer 5 years straw hat factory 4 years foundry labourer 2 years sand blaster (steel and iron castings) 8 years millwright s mate 3 years, shotblaster (iron castings) 3 months

History of illness In good health up to May 1934, consulted doctor on account of ...

... and pain in the right side Percussion note impaired in midzones Respiratory murmur harsh vesicular, râles right midzone posteriorly, pleural rub right base Died 26 10 38

X-ray examination 7 7 37 (See Plate IX) Heart central not enlarged, right diaphragm blurred, left clear, generalised fine nodulation with focal emphysema, confluent opacities left subclavicular region and right base with clear areas suggesting cavitation

Autopsy Pleural cavities completely obliterated by fibrous adhesions Right lung large and solid, caseating mass connected with abscess near the diaphragm On section lung seen to consist of a mass of caseating tuberculous nodules, many of them coalescing to form abscess cavities Remaining lung substance hard and gritty with fibrous silicotic nodules Left lung showed extensive caseation and silicotic nodules, some of which had become confluent Bronchial and tracheal lymph glands filled with pigment and hard gritty material and fibrosis Three of upper abdominal aortic glands similarly infiltrated

... peribronchial fibrosis was also present

Comment Massive silicosis accompanied by tuberculosis

(44). Male. Age 32 years

Occupational history Shotblaster in Sheffield steel foundry since 16 years of age No other occupation

Died January 1947

Gross morbid anatomy Very extensive tuberculosis of lungs with chronic ...

... at least in part tuberculous Emphysema of anterior lower parts of both lungs

Histological sections Numerous single and conglomerate fibrous nodules, most of which had a caseous centre and were obviously tuberculous Some smaller nodules possibly purely silicotic There was old as well as recent tuberculosis In a hilar lymph gland there was dissociation of agents, with definite purely silicotic nodules and purely tuberculous ones Incinerated sections showed only small to moderate amounts of iron around but not in nodules Diagnosis silico-tuberculosis

Chemical analysis Ash 7 50 per cent of dry weight Total silica 0 87 per cent of dry weight Free silica 0 17 per cent of dry weight Iron as Fe_2O_3 0 16 per cent of dry weight

Comment Nodular silicosis with tuberculosis

(45) Male. Age 46 years

Occupational history Sandblaster for 10 years in a steel foundry

History of illness For 7½ months complained of increasing dyspnoea on exertion and for 2½ months of retrosternal pain after 150 yards walk, relieved

FIG 36 QUIESCENT TUBERCULOUS NODULE MIXED DUST PNEUMOCONIOSIS X25 Case 23, Chap V

FIG 37 NODULE OF MIXED DUST PNEUMOCONIOSIS TYPE X42 Case 24, Chap V

History of illness Died suddenly (22 1 47) from coronary thrombosis

Gross morbid anatomy Fibrous thickening of pleura over both apices and left lower lobe slightly raised small white hard plaques over remainder Very pigmented lungs Fairly marked emphysema with bullae anteriorly Very hard rubbery masses at both apices, roughly hemispherical 1 inch diameter, fused nodules up to ½ inch in upper lobes, small nodules in lower lobes No evident tuberculosis Large black glands at hilum with hard areas in them

Histological sections (Fig 43) Marked silicosis with aggregations of nodules Emphysema, with some fibrosis of alveolar walls Marked *pigmen-*

Chemical analysis Ash 7 87 per cent of dry weight Total silica 2 60 per cent of dry weight Free silica 0 69 per cent of dry weight Fe_2O_3 1 43 per cent of dry weight

Comment Massive silicosis with emphysema Died from coronary thrombosis

(48) Male. Age 51 years

Occupational history Sandblaster at a small arms factory for 3 years Prior to that had worked in the "browning shop" of this factory

... expectoration, and shortness of breath
16 3 43 on admission to hospital
lyspnoea on exertion which had
r He had had a cough for six
There had been no recent loss
left
unds
the

sputum

... fibrosis of both lungs with mottling
On discharge
ed and he had
spital

... both sides ex-
left upper lobe
inal glands pig
pericardial sac
aseous and cal
and abdominal

viscera

... and conglomerate nodules of silicosis in lungs
lli) in lungs and liver
rculosis with terminal

dissemination

(49) Male Age 52 years.

Occupational history Sandblasting and zinc spraying (metal window frames) 14 years

History of illness Ceased work in 1938 owing to chest trouble (dyspnoea), awarded compensation same year *Gradually got worse* and was admitted to hospital 20 3 44 and died 28 4 44

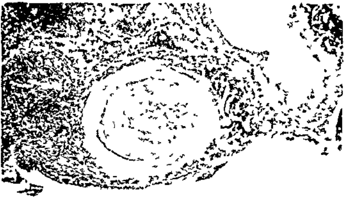


FIG 36 QUIESCENT TUBERCULOUS NODULE MIXED DUST PNEUMOCONIOSIS X25 Case 23, Chap V

FIG 37 NODULE OF MIXED DUST PNEUMOCONIOSIS TYPE X42 Case 24, Chap V

FIG 38 LOBAR PNEUMONIA SMALL AREAS OF PERIVASCULAR AND PERIBRONCHIAL FIBROSIS CONTAINING DUST PARTICLES X50 Case 24, Chap V

FIG 39 PARTICLES OF IRON OXIDE IN INCINERATED SECTION OF LUNG X250 Case 24 Chap V

FIG 40 MASSIVE SILICOSIS EMPHYSEMA
X5 Case 35 Chap V

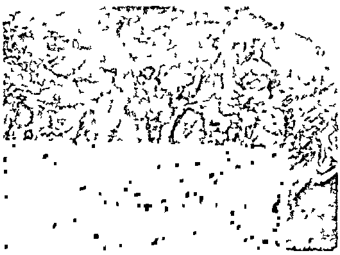


FIG 41 SILICOTIC NODULATION EMPHYSEMA
X10 Case 35 Chap V

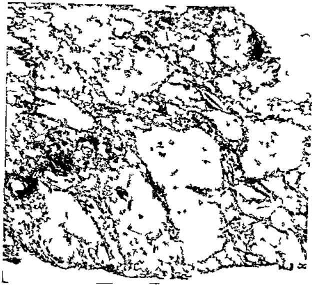


FIG 42 MIXED SILICO TUBERCULOUS NODULES
X5 Case 36, Chap V

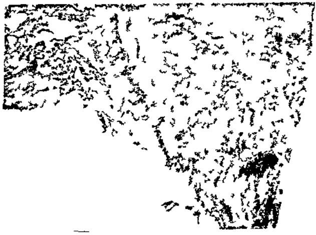


FIG 43 MASSIVE SILICOSIS X5 Case 47 Chap V

FIG 44 SILICOTIC NODULE EARLY CALCIFICATION OF COLLAGEN FIBRES X42 Case 55, Chap V

FIG 45 SILICOTIC NODULES WITH EARLY CALCIFICATION EMPHYSEMA X5 Case 55 Chap V

FIG 46 SILICOTIC NODULE WITH CENTRAL NECROSIS (NON-TUBERCULOUS) X24 Case 62, Chap V

Gross morbid anatomy Autopsy 2 5 44 Pleurae much thickened with

Histological sections Extensive conglomerate nodules of silicosis in lungs, terminal fibrinous pericarditis

Comment Massive silicosis with emphysema Death from congestion of the lungs, pleural effusion, fibrinous pericarditis and congestive heart failure

(50) Male. Age 58 years.

Occupational history After various occupations was a sandblaster for 16 years – 1903–1904, coal delivery, 1904 1905 restaurant assistant, 1905 1915, cabinet maker's assistant 1915–1919 engaged in small arms manufacture, 1929–1945 sandblaster of motor engine castings (cabinet blasting with compressed air, using crushed flint and wearing protective helmet) Castings cement, steel, brass, aluminium and gun metal Castings rough cast before they came to him but often contained black sand cores Shot substituted during last 3 months of employment

History of illness Examined by Silicosis Medical Board in 1945 and certificate of total disablement issued Had always been healthy until the last six years since when he had been subject to recurrent chronic bronchitis Lost considerable time in winter owing to asthma for which he was treated in hospital Died 13 8 47

X ray examination. (See Plate X) 14 8 46 Barrel shaped chest Nodular shadows distributed throughout both lung fields, the individual nodules not being very dense Nodules more closely sewn in basal areas Whole film has a translucency which suggests the presence of emphysema

Gross morbid anatomy Autopsy Clubbing of fingers and toes Pleura Dense adhe[illegible] upper lobe Extra pulmonary main bronchi showed

Histological sections Lungs exhibited discrete and conglomerate nodules of silicosis together with tuberculosis in various stages of evolution Giant cell systems of tuberculosis in liver

Comment Nodular silicosis and focal emphysema accompanied by tuberculosis (pulmonary and abdominal)

(51) Male Age 58 years

Occupational History Employed at one factory (Foundry T) for 36 years first 26 years sandblaster, last 10 charge hand labourer emptying emery tanks etc

History of illness Became ill 2 years ago frequent attacks of bronchitis No other details

Gross morbid anatomy Well marked clubbing of fingers, evidence of pneumoconiosis with cardiac failure, lungs referred for section, they showed nodular silicosis with confluent areas, thickened pleura on left and congested bases

Histological sections Conglomerate nodules of silicosis and pneumonia Hilar gland also showed conglomerate silicotic nodules

Comment Nodular silicosis with confluent areas and pneumonia in red hepatization stage

(52) **Male** *Age 62 years*

Occupational history Sandblaster 1932 1937 Worked alone in cabinet 8 ft × [illegible]
finished
ceased
occupations

Gross morbid anatomy (Abstract of autopsy report) Pleura recent pleurisy over lower parts of pleura on both sides with scarring and contraction of visceral portions over upper lobes Lungs Many emphysematous bullae trachea and main bronchi filled with muco pus, bronchiectasis both lower lobes, nodular silicosis in all lobes Heart dilated, no valvular lesions

Histological sections Lungs showed many conglomerate nodules of silicosis

Comment Nodular silicosis with emphysema and bilateral bronchiectasis

(53) **Male** **Age 53 years**

[illegible] he began work

from dust on account of silicosis

History of illness Diagnosed silicosis 15 3 45 No further details available Died 16 12 1946

Gross morbid anatomy (Abstract of autopsy report) Marked oedema of legs Pleura very dense adhesions at left apex and over anterior portions of right [illegible]

Histological sections Massive conglomerate nodulation of silicosis [illegible] marked perivascular and peribronchial fibrosis but little pigment

Comment Massive silicosis with emphysema terminating in congestive heart failure and anasarca This case illustrates the rapid onset of silicosis in sandblasters There was only 5 years exposure

(54) **Female** **Age 41 years** **Married woman, six children**

Occupational history Sandblaster at armaments factory in World War I Length of service not known

History of illness Good health until a few weeks before death when she had a severe haemoptysis No tubercle bacilli found on repeated examination of sputum Died in hospital after severe haemoptysis

X ray examination Reported as fibrosis of lungs

silicotic nodules

Histological sections Numerous discrete and conglomerate nodules of sil cosis and caseous areas in lungs

Comment Massive silicosis accompanied by tuberculosis (pulmonary) *This is the first woman sandblaster known to have died from silicosis*

(55) *Female Age 36 years*

Occupational history Sandblaster at an iron foundry from 16 to 29 years of age (13 years in all) *She then married and moved to another part of England* and had done no other factory work

History of illness Seven years later (in 1948) she became acutely ill and died in May 1948 During the seven years she had become progressively short of breath

of the fingers lower limbs oedematous
ight
ulti
wed
ower
ung
gritty
d nodules of
pigmented fibrosis surrounded by emphysema lules appeared
to be calcified and were difficult to cut

A mass of fibrotic lymph glands in the splenic pedicle

Histological sections (Figs 44 and 45) Perivascular peribronchial and some perialveolar fibrosis many conglomerate nodules of silicosis pleura less affected portions of the lungs show congestion,
is but there were one or two
ting healed tubercles Within
haematoxylin as though some

Ash 22 72 per cent of dried lung Total silica 0 42 per
dried lung Fe_2O_3, 0 11 per cent
ing Phosphorus 3 70 per cent
of dried lung

Comment Conglomerate nodular silicosis with perivascular, peribronchial and perialveolar fibrosis This is the second death from silicosis in a woman sandblaster to be reported

(56) Male Age 36 years

Employed in an iron foundry for last 16 years of his
approximately 3
3 years as super
of small amounts
y shovel under a
)36 Probably had
l out by propelling

the sputum towards the end of his illness Died 7 4 40 In receipt of compensation

Gross morbid anatomy (Abstract of autopsy report) Fingers clubbed Pleura adhesions at both bases Lungs Massive silicosis involving all lobes emphysematous bullae both apices old dry cavity in right lower lobe

Histological sections Sections of lungs showed massive conglomerate nodulation of silicosis no evidence of tuberculosis

Comment Massive silicosis with bullous emphysema and dry cavity of indolent tuberculosis

(57) Male Age 35 years

never took any precautions

History of i

pneumonia in

Admitted to

silicosis No

disease of lung was also discussed

charged 29 11 34 Re admitted cy

on the following day

X ray examination Film taken in 1934 showed advanced silicosis with suspicion of pulmonary neoplasm as well

Gross morbid anatomy (Abstract of autopsy report) Pleura old adhesions at both bases, with extensive subacute pleurisy Lungs very extensive nodular

Histological sections Pleura was enormously thickened with fibrin which here and there contained collections of leucocytes the fibrin was beginning to organize with formation of collagenous fibres and new capillaries In deep layers of pleura silicotic nodules were present

tis

pneumonia

newhat unusual distribution lobes) with minimal tuber and broncho pneumonia

(58) Male Age 55 years

38 years, obs the l rubber

lasting his had with ex

diagnosed. Died *9 4 43*

X ray examination Report stated Long standing silicosis with signs at right upper lobe of ?tuberculosis ? collapse

Gross morbid anatomy (Abstract of autopsy report) Pleura old adhesions at left apex recent pleurisy at base, Lungs Massive silicosis right and left upper lobes with nodules in lower lobes, subpleural nodules also emphysema of focal type, fibrocaseous tuberculosis in both upper lobes and right lower, with cavities in left upper lobe, area of terminal pneumonia in left lower lobe

Histological sections Microscopical examination of lungs confirmed the presence of tuberculosis conglomerate nodules of silicosis some of which had caseous centres, numerous asbestosis bodies were found also but the histological picture was that of typical silicosis with tuberculosis hilum gland contained conglomerate nodules of silicosis almost entirely replacing normal lymphoid tissue Aorta showed extensive collagenous thickening of media and round cell infiltration of vasa vasorum

Comment Massive silicosis with emphysema accompanied by tuberculosis and syphilis of aorta Terminal pneumonia Although typical asbestosis bodies were found in sections no history of exposure to asbestos could be obtained

(59) Male Age 42 years

Occupational history Sandblaster for 25 years at Foundry N

History of illness Three abdominal operations for gastric and duodenal ulcers No details of chest illness until admission to hospital October 1945 with septic pneumonia from which he died

Gross morbid anatomy (Abstract of autopsy report) Trachea and main bronchi filled with muco pus Pleura Dense adhesions lower part of left and apical portion of right sac [illegible]

meningitis

Histological sections The meninges and pus from the basal lung cavity contained tubercle bacilli and streptococci Discrete and conglomerate nodules of silicosis were present in the lung tissue

Comment Nodular silicosis accompanied by pulmonary tuberculosis with dissemination to meninges and a terminal streptococcal infection of a tuberculous pulmonary cavity

(60) Male Age 31 years

Occupational history Sandblaster 1927–1933 followed by 1½ years as zinc sprayer Further details not known

History of illness No details known Examined by Silicosis Board 29.9 36 and certificate of total disablement on account of silicosis accompanied by tuberculosis (sputum contained T B) issued

[illegible]

of silicosis and tuberculosis

Comment Nodular silicosis accompanied by pulmonary tuberculosis with cavity formation Death from congestive heart failure

VI MISCELLANEOUS

(61) *Male. Age 47* years

Occupational history Descaler at steel foundry for 14 years Previously had been a bricklayer (houses) Descaling is the *removal of iron oxide scale* from castings by dipping them in dilute HCl

History of illness Dry cough for past few months Died from coronary *thrombosis in Feb 1947*

Gross morbid anatomy Marked generalised emphysema Pigmentation only moderately marked emphysema more apparent in the areas of pigmentation No very definite palpable nodules Hilar glands somewhat enlarged, black and firm

Histological sections Emphysema *Bronchitis Signs of congestive failure*

in bron-

Pigment

0 45 per

0 30 per

cent of dry weight

(62) Male. Age 61 years.

Occupational history Furnace bricklayer's labourer for 25 years in a steel foundry No other details available

History of illness "Chesty" for many years – bad cough and dyspnoea unable to work for 5 months before his death in January 1947

Gross morbid anatomy Emaciated Large left empyema Marked oedema

Dilated right heart Chronic venous congestion

irly soft There were a

Hilar glands moder-

After fixation, pleura over right lung was blue black, mottled with fine white spots

Histol

lungs an

culosis

Chemi

cent of d

of dry weight

Comment Early nodular silicosis with dust reticulation, emphysema and *bronchiectasis* Died from purulent empyema

(63) Male. Age 61 *years*

Occupational history Core maker in an iron foundry for 40 years At the *present time only non siliceous parting powders are used in the foundry*

History of illness Admitted to hospital 1 12 46 with a history of cough and dyspnoea 6 months, weakness 8 months, loss of weight (28 lbs in 8 weeks), abdominal pain *and constipation 2 weeks Previous cholecystectomy* Clinical diagnosis of carcinoma of bronchus and collapse of right lung Died 12 12 46

Gross morbid anatomy Severe emphysema and fibrosis, chronic bronchi-

lung very uneven and of loose spongy texture with scattered raised areas of

nodes, no caseation or calcification Other organs showed effects of venous congestion There was slight hypertrophy (0 5 cm) of right ventricle

Laboratory investigation Only the left lung was received After fixation this showed a beautiful blue grey mottling of the pleura

Histological sections Bronchiectasis, emphysema Severe broncho-pneumonia, some of it organising No evident tuberculosis Fibrosis mostly of inflammatory (infective) type a little fibrosis of dust reticulation" type, no silicotic nodulation Much of pigment too opaque to stain, mainly in intra-alveolar phagocytes, incineration reveal d that most of this pigment was *iron*.

Chemical analysis Ash 4 07 per cent of dry weight Total silica 0 42 per cent of dry weight Free silica 0 35 per cent of dry weight Fe_2O_3, 0 56 per cent of dry weight

Comment Minimal fibrosis of dust reticulation type accompanied by emphysema and bronchiectasis Death from broncho pneumonia The case illustrates the low silicosis risk to coremakers who do not use silica parting powders

(64) Male. Age 38 years.

(dusty job) As iron moulder probably used silica parting powders, but no definite information on the point Iron moulder 16 years Steel furnaceman 3 years

Family history Nil relevant no history of tuberculosis

Previous health Appendicitis at 15 years of age pneumonia (10 months illness at 37 years of age)

History of illness Recalled to army in 1944 but broke down in health X rayed, pneumoconiosis diagnosed and discharged Since then became increasingly short of breath with paroxysmal cough and pains in the chest Diagnosed as having silicosis by Silicosis Medical Board on 28 5 45 Died 11 6 48

X ray examination (Plate XI) 25 5 45 Generalised coarse nodulation both lung fields with coalescence both upper lateral zones No shadows sug

Large tuberculous right lung Tuber ions with confluent areas throughout both lungs

Histological sections (i) from lower lobe left lung and (ii) from gland Both showed extensive tuberculous caseation and conglomerate nodules of silicosis

Comment Silicosis and tuberculosis This man had been employed in two occupations in each of which there is a risk of silicosis. He was employed longest at iron moulding (16 years) and only 3 years as a steel furnaceman It is likely that the main exposure to the dust of free silica occurred during his employment as an iron moulder

Discussion

give no demo an four-fifths of our cases showed nodular silicosis and about one-third mass ve silicosis

Nodular silicosis varied greatly in degree in different lungs and we have found it impossible to devise any classification that would give an accurate assessment of the extent of the lesions We have therefore been content with a simple

masses they occupied the often bilateral As a rule their cut surface was smooth and glossy The masses the lungs

volved in a tuberculous or other uncommon to find massive silicosis without smaller nodules being present in other parts of the lungs

"Dust reticulation" was recorded in 22 cases, in 7 of which no nodular silicosis was demonstrated These figures understate the frequency of the condition because many of the case reports date from a period before this type of fibrosis was recognised as an entity Furthermore it was often not recorded when other gross lesions were present

"Dust reticulation" is in our view an unsatisfactory term The word "reticulation" was used as long ago as 1853 by Busk and Huxley, in their English edition of Kolliker's *Manual of Human Histology*, [100] to describe a net like distribution of connective tissue without reference to origin, and the word has been frequently used in this sense since that time Snow Miller, [99] employing the new silver technique, noted the formation of reticulin in pulmonary tuberculosis in 1923 and it is now recognised in other forms of non industrial fibrosis of the lungs Moreover, the lesion as seen at autopsy does not consist mainly of reticulin but of collagen fibres which do not stain black with silver and it is these fibres which are chiefly responsible for the impairment of respiratory function during life Lastly, the word "reticulation" is used by radiologists to describe a particular pattern of shadows in the lung and there is no certainty that these shadows accurately represent fibrosis as seen by the morbid anatomist

At the same time a pathological term is obviously needed to designate the characteristic distribution of reticulin and collagen found in the pneumoconioses, viz a perivascular, peribronchial, interlobular and subpleural arrangement of cells, fibres and dust particles growing into large irregular patches in the later stages of the disease but without the sharply defined whorled nodule of classical

are mixed, and for the purposes of this memorandum "mixed dust pneumoconiosis" appears to be the more suitable term, though we recognise that it would not apply to some of the experimental lesions produced by pure dusts

The involvement of the hilar lymph glands is an almost invariable finding in silicosis and its frequent presence in our cases needs no special comment.

The histological features of the silicotic reaction followed well recognised lines with the whorled
to silver impregnation
like strands of old wet r
attempt at whorling and its irregular outline was not as prominent a feature as in the lungs of coal workers and the typical medusa-head type of nodule of these latter was rarely seen There was, however, perivascular and peribronchial deposition of reticulin and collagen fibres as is seen in the lesion of dust reticu lation, though it seldom reached an extreme degree As stated above, we believe this to be a feature of the reaction to a great number of mixed dusts and we prefer to call it ' mixed dust pneumoconiosis '

The silico tuberculosis found in this series of cases was similar to that described by others and the nodule is an obvious compromise between the two processes of tuberculous caseation and the silicotic type of whorled fibrosis

specific concomitant of dust reticulation As a rule the nodules of nodular tuberculosis had more concentrically arranged fibres and these were thinner and more delicate in appearance than the sturdy rope like strands of the well developed silicotic nodule
particles though when vie

n the dusts inhaled and their mixed
re difficult to evaluate It is
ely black in transmitted light
n or iron oxide Inhaled iron
assium ferro
rt to give an
herefore that
vas by exam
ining incinerated sections in reflected light It was then surp g to find that much of what one took to be carbon remained as a yellow, orange or red pigment In our experience this is true not only of the lungs of foundry workers
Crystalline silica was demonstrated
sections viewed in polarised
ich were not crystalline silica
larly polyhedral scale like or
n but were mainly combustible
imilar to the structures des
cribed in coal miners by
(91) and by Williams (1934) (92)
and 1939) (93) and also in the lungs of graphite workers by Harding and Oliver (1949) (107)

this method (and of others) but in our experience it gave useful answers

Pulmonary complications of silicosis and mixed dust pneumoconiosis Tuberculosis as a complication of silicosis and mixed dust pneumoconiosis has been discussed above but there remain some other complicating lung diseases which deserve mention

Bronchial carcinoma was found in three cases with silicosis This finding accords with the high incidence noted in other silicotic groups It must be remembered, however, that we are dealing with a specially selected group whose lungs were more closely examined than those of the general population

Pneumonia and broncho-pneumonia occurred as a terminal event in 15

Other complications Atheroma of the coronary arteries occurred in 6 cases (2 with sudden death) and only one case of valvular disease of the heart was found Nephritis was present in 4 autopsies Single examples of cerebral haemorrhage, gangrenous appendix with peritonitis, B Coli infection with haemolytic jaundice, adherent pericardium and peptic ulcer were also recorded

CONCLUSIONS

The lungs of workers in iron and steel foundries examined show a pneumoconiosis resulting from inhalation of mixed dusts The silica in these dusts plays a preponderant part and frequently produces the typical appearances of nodular and massive silicosis The iron and other constituents, however, tend

Wales coal-workers

Of the sequelae and complications, frank open pulmonary tuberculosis is

Emphysema was a common accompaniment (as it is indeed of practically all pneumoconioses) Both bullous and focal emphysema were found, but the latter was not as conspicuous a feature as it is in coal-workers

from another cause

type We have been able to include only one furnace bricklayer s labourer in the series but he had early nodular silicosis with mixed dust pneumoconiosis Evidence presented elsewhere in this report shows that furnace bricklaying and dismantling may lead to silicosis

Our one case of a carbon arc welder who had worked in a steel fettling shop is important in that he developed slight silicosis and widespread mixed dust pneumoconiosis after being exposed for 34 years to the dust in the general atmosphere of the shop

CHAPTER VI

RECORDS OF PULMONARY DISEASES IN FOUNDRY WORKERS

BY A I G McLAUGHLIN AND C L SUTHERLAND

The following information covering the period 1931 1947 about the occurrence of industrial pulmonary disease in foundry workers has been collected from the files of the Factory Department and of the Silicosis and Asbestosis Medical Board Owing to the fact that silicosis and pneumoconiosis are not notifiable under the Factories Act the Factory Department depends on such sources of information as the Registrar-General who furnishes to the department the names and occupations of all cases dying from fibrosis of the lungs, secretaries of trades unions who submit the names of their members who have been diagnosed as having silicosis or other fibrosis of the lung and some medical practitioners who are under the impression that industrial fibrosis of the lungs is notifiable Individual members of the Medical Branch also discover cases during their visits to factories or through contact with hospital staffs,

[illegible]

the silicosis, asbestosis or pneumoconiosis compensation schemes As far as foundries are concerned, only steel fettlers or dressers in steel foundries come under the schemes at present and iron foundry workers do not Sand – or

[illegible]

some names occurring in one list and not in the other It is probable, however, that some cases do not come to the notice of either department

FETTLERS OR DRESSERS OF STEEL CASTINGS

Between 1931 and 1947, 81 fettlers or dressers of steel castings died from silicosis with or without tuberculosis The figures year by year, are given in the following table —

from proceeding with their claims on account of this legal difficulty. The great increase in applications and certificates in 1942 came mainly from one firm where the sandblasters and fettlers were X rayed at intervals. On the findings they were recommended to change their occupations and in due course made applications to the Silicosis Medical Board. But apart from this there was a general increase of cases certified as having silicosis in the later years. Another factor in the increase of cases of silicosis is the use of pneumatic tools instead of the older method of cleaning the castings with the hand hammer and chisel. In some foundries the pneumatic chisel was introduced about 1913 but it came into more general use in the late 1920's. Nowadays few fettlers of steel castings use the hand hammer and chisel. A casting can be cleaned more rapidly with a pneumatic tool and in consequence there is a great evolution of dust. Further the pneumatic tool imparts a much heavier blow to the castings and the sar
a great inci
inside the c
was a mark
and anti gl
the war
steel fettlers will probably not be seen for about 10 – 15 years

IRON DRESSERS (FETTLERS)

Over the same period (1931 – 1947) information was obtained about 7 fettlers of iron castings who died from silicosis with or without pulmonary tuberculosis (4 silicosis, 3 silicosis and tuberculosis). These deaths occurred in 1935 (1 case), 1937 (1), 1938 (1), 1939 (1) and 1944 (3 cases), only one of these, a fettler of malleable iron castings was seen by the Silicosis Medical

previously stated, workers in iron foundry processes do not come under the silicosis compensation schemes

In the section on pathological investigations will be found descriptions of 7 more iron dressers or grinders who died from various lesions of the lungs

1. *Iron fettler* – died from tuberculosis with some silicotic nodulation
2. *Iron fettler* died from broncho pneumonia supervening on pneumoconiosis
3. *Grinder of iron castings* – died from carcinoma of the lung and silicosis
4. *Iron fettler* – died from tuberculo silicosis
5. *Fettler (barreller)* of malleable iron castings – died from a typical silicosis

ust pneumo-

a mixed dust

pneumoconiosis

the 7 cases 2 fatalities occurred in men who had had a mixed

brass castings dresser, died

44, an iron castings dresser

of death being silicosis

Non fatal cases amongst iron dressers and grinders of pneumoconiosis or silicosis with or without tuberculosis are given in the following list —

	Year	Age	Foundry	Exposure	Diagnosis
1	1935	32	Iron Foundry, Birmingham	8 years	Silicosis
2	1936	36	Malleable Iron Foundry Walsall	16 years	Silicosis
3	1937	61	Iron Foundry Willenhall	40 years	Silicosis and Tuberculosis
4	1937	36	Malleable Iron Foundry Walsall	16 years	Silicosis
5	1937	33	Iron Foundry, Walsall	16 years	Pneumoconiosis ? Silicosis
6	1938	70	Malleable Iron Foundry Dagenham	48 years	Silicosis
7	1939	43	Iron Foundry Birmingham	22 years	Pneumoconiosis
8	1939	27	Iron Foundry Dagenham	4½ years	Pneumoconiosis Tuberculosis ?
9	1941	44	Malleable Iron Foundry Derby	16 years	Pneumoconiosis
10	1943	57	Iron Foundry Stamford	20½ years	Pneumoconiosis
11	1944	58	Series of Iron Foundries Luton	42 years	Pneumoconiosis
12	1945	47	Malleable Iron Foundry Tipton	22 years	Tuberculosis and pneumoconiosis
13	1946	41	Malleable Iron Foundry Tipton	22 years	Tuberculosis ? and pneumoconiosis
14	1946	39	Iron Foundry Dagenham	19 years	Pneumoconiosis
15	1946	39	Iron Foundry Stowbridge	22 years	Pneumoconiosis ? Silicosis
16	1946	54	Malleable Iron Foundry Derby	38 years	Pneumoconiosis ? Silicosis
17	1946	66	Iron Foundry West Bromwich	33 years	Pneumoconiosis

Records of the following non fatal cases in men who had mixed exposures are given in the following list —

	Year	Age	Foundry	Exposure	Diagnosis
1	1937	30	Mixed Foundry Walsall	Surface grinding iron and steel (clean castings) 11 years	Pneumoconiosis and tuberculosis
2	1937	47	Mixed Foundry (T), London	Sandblasting iron 4 years, Furnaceman steel 8 years Grinding steel 3 years Moulder 3 years	Silicosis and tuberculosis
3	1941	55	Mixed Foundry Peterborough	Iron and Brass fettler 39 years Steel fettler 1 year	Silicosis
4	1942	51	Mixed Foundry Peterborough	Iron fettling 33 years Steel fettling 3 years	Silicosis
5	1943	44	Mixed Foundry Peterborough	Iron fettling 24 years Steel fettling 4 years	Early silicosis

MOULDERS

Steel Moulders No cases of silicosis or silicosis with tuberculosis appear in the records of the Factory Department or the Silicosis Medical Board In the [illegible] ioulder [illegible] whose [illegible]

TABLE XLI IRON MOULDERS – DEATHS FROM SILICOSIS ETC

Year	Silicosis	Silicosis and Tuberculosis	Total	Remarks
1931	1*	—	1	* Iron moulder s labourer
1932	—	—	—	
1933	—	—	—	
1934	1	—	1	
1935—1942	—	—	—	
1943	1*	—	1	* Described in Chap V
1944	—	2*	2	* Described in Chap V
1945	1	3*	3	* Two of these cases described in Chap V
1946	2*	—	2	* One case described in Chap V
Totals	6	5	10	

In addition 15 non fatal cases of pulmonary disease amongst iron moulders have been investigated Details are given in the following list —

	Year	*Age*	*F u idr*	*Exposure*	*Diagnosis*
1	1937	51	Iron Moulder Malleable Iron Foundry Walsall	38 years	Pneumoconiosis ? Silicosis
2	1939	20	Asst Moulder Malleable Iron Foundry Derby	3 years	Pulmonary Tuberculosis ? Silicosis
3	1944	52	Iron Moulder Willenhall	30 years	Silicosis
4	1944	43	Iron Moulder Leeds	25 years	Silicosis
5	1945	47	Iron Moulder Tipton	30 years	Pneumoconiosis ? Silicosis
6	1945	42	Iron Moulder and Caster Walsall	20 years	Silicosis
7	1945	44	Iron Moulder Luton	17 years	Silicosis
8 to 15	1944		8 Iron Moulders in Iron Foundry (see below)		Silicosis

The first 7 cases complained of chest symptoms and the remaining 8 were discovered during an investigation following 3 deaths from silicosis amongst iron moulders in the foundry

It is not suggested that the small number of recorded cases of silicosis, tuber- [illegible]

One of us (A I G McL) with K Biden Steele examined the other workers in the moulding shop 21 moulders and 13 assistant moulders The following is a summary of the results of the investigation (Report dated 24 11 44)

1 Of 21 moulders in this iron foundry 8 have contracted silicosis In all 8 cases there is X ray evidence of nodulation

2 Ten cases have X ray reticulation and in 2 of these a clinical diagnosis of silicosis is probably justified

3 One moulder has fibroid pulmonary tuberculosis with cavitation In addition his X ray film shows reticulation

4 Two moulders have an X ray appearance of increased linear striation but they had been exposed to the dust for less than 10 years Another moulder with a 7 year exposure showed early X ray reticulation

5 All moulders exposed to the dust for 10 years and over show X ray evidence of reticulation reticulo nodulation or nodulation In all these cases the tolerance to exercise is reduced in varying degree

6 The exercise tolerance test appears to be a useful method of assessing the extent of lung damage and the degree of disability

7 Of 13 assistant moulders those exposed to the dust for under 2 years show no abnormality In those exposed over 2 years the X ray appearance is that of increased linear striation or (in 2 cases) early reticulation

8 [illegible]

dust inhaled

9 It is suggested that under these conditions a diagnosis of silicosis can be made when the X ray film shows reticulation with little or no nodulation, when the clinical features, including the estimation of the tolerance to exercise, are also taken into account

SANDBLASTERS AND SHOTBLASTERS

It is well known that sandblasters are exposed to a serious risk of silicosis with or without tuberculosis and that the disease runs a more acute course than in any other silicosis producing occupation with the exception of the manufacture of abrasive silica soaps Further reference is made to this point on page 222 The introduction of steel shot instead of sand for the blasting of

castings together with the introduction of better methods of dust control, has materially lessened the silicosis risk by reducing the amount of free silica in the air

The following tables show the numbers of sandblasters coming to the notice of the Silicosis Medical Board since 1931 It should be pointed out that not all of these are workers in foundries, but the process is essentially the same in all industries In foundries the castings are blasted to remove adherent sand and scale, whereas in other industries clean articles may be blasted for such purposes as the etching of glass, to prepare the surface of metal articles preparatory to the application of paint and vitreous enamel and to secure a smooth finish

TABLE XLII SAND AND SHOTBLASTERS APPLICATIONS FOR CERTIFICATES OF DISABLEMENT

Year	Total Disablement from		Suspension	Refusal	Total
	Silicosis	Silicosis and Tuberculosis			
1931	1	—	—	—	1
1932	—	6	1	6	13
1933	2	—	2	2	6
1934	2	2	3	3	10
1935	7	2	1	4	14
1936	3	6	2	2	13
1937	4	1	1	8	14
1938	3	4	2	5	14
1939	1	3	1	3	8
1940	3	1	1	2	7
1941	5	3	1	3	12
1942	2	—	1	5	8
1943	2	—	1	3	6
1944	1	2	1	4	8
1945	1	—	4	4	9
1946	2	—	3	8	13
1947	2	3	4	11	20
Totals	41	33	29	73	176

The following table gives the number of deaths from silicosis and silicosis with tuberculosis in sand and shotblasters

TABLE XLIII SAND AND SHOTBLASTERS – DEATHS

Year	Silicosis	Silicosis and Tuberculosis	Other causes	Total
1931	—	2	2	4
1932	1	1	—	2
1933	—	5	—	5
1934	1	1	—	2
1935	1	3	—	4
1936	2	5	—	7
1937	2	1	2	5
1938	2	4	—	6
1939	2	2	1	5
1940	2	1	—	3
1941	2	1	—	3
1942	2	4	—	6
1943	1	2	—	3
1944	2	2	1	5
1945	1	5	1	7
1946	1	3	1	5
1947	1	1	5	7
Totals	23	43	13	79

When the figures for steel dressers and blasters (shot or sand) are compared, it will be seen that the cases of silicosis and silicosis with tuberculosis amongst the latter have not increased year by year, whereas those for the former have risen yearly The blasting processes are subject to regulations designed to control the dust and protect the worker, whereas steel fettling by pneumatic h[illegible]
s[illegible]
[illegible]
it[illegible]
d[illegible]
Foundries Committee The absence of dust control methods for steel fettling may partly explain the increase of recorded cases of silicosis amongst the workers

SHOT AND SANDBLASTERS IN IRON FOUNDRIES

The figures of deaths and cases of silicosis and silicosis with tuberculosis amongst blasters (shot or sand) include those who worked on iron castings. *The health risk to blasters of steel castings is well known but it should be emphasized that blasters of iron castings are exposed to a similar risk.* The following cases, some of whom have had a mixed exposure, illustrate the point.

1 MALE aged 58 years, seen first by the Silicosis Medical Board in 1937.

dyspnoea and pain in the left side of the chest

2 MALE aged 29 years First seen by the Silicosis Medical Board in 1935.

Medical Board he was found to have dyspnoea on slight exertion, cough, expectoration and pain in the chest There were few abnormal physical signs "any fibrosis being so diffuse and uniform as not to be apparent clinically". *X-ray examination showed the presence of dense shadows at the lung roots* with generalised fine discrete closely-set mottling throughout both lungs, the picture being consistent with a diagnosis of classical silicosis

3 MALE aged 37 This man had been an underground coal miner *in the* Rhondda Valley for 20 years and a sandblaster of iron castings for 2½ years. On routine X-ray examination in 1938 he was found to have fine classical nodular silicosis It is not possible to determine which of his occupations *had* caused the silicosis, but the X-ray appearances were not like that of a coal-miner's lung On the other hand the period of exposure to sandblasting was short

4 MALE aged 56 years Seen by the Silicosis Medical Board in 1945 He

including

examination showed the presence of generalised reticulo nodulation with increased translucency at the left base A diagnosis of silicosis and emphysema was made

METAL GRINDERS

The serious risk of lung disease amongst metal grinders was clearly demonstrated in 1923 by Middleton on whose report (with Macklin) the Grinding of

forms of pneumoconiosis

The cases of silicosis and/or tuberculosis amongst metal grinders coming to

FURNACE DISMANTLERS AND BRICKLAYERS

Furnaces and ladles have to be lined with a refractory material which in

Silicosis Medical Board since 1938 when the High Court decided that the process came within the silicosis compensation schemes Since that date up to the end of 1947, 34 cases of silicosis with or without tuberculosis have come to the notice of the Board. The yearly distribution of the cases is shown in the following table

TABLE XLIV SILICOSIS AND TUBERCULOSIS IN FURNACE DISMANTLERS AND BRICKLAYERS SILICOSIS MEDICAL BOARD

Year	Silicosis	Silicosis and Tuberculosis	Total
1938	3	1	4
1939	2	—	2
1940	1	1	2
1941	—	1	1
1942	3	1	4
1943	—	—	—
1944	1	1	2
1945	4	—	4
1946	8	1	9
1947	5	1	6
Totals	27	7	34

... and the average length

1 MALE, employed by a Sheffield steel firm for 24 years as a bricklayer ... dismantler of furnaces He complained of chest symptoms and his X-ray film ... in the upper lobe of the right lung with nodular shadows

... el furnaces
... evidence)
... psy.

schemes ... attendant in a Gloucester-
... years as a
... lining of
... year had
... uch work
... pain and

dyspnoea. X-ray examination suggested the presence of silicosis and tuberculosis and the diagnosis was supported by the Silicosis Medical Board Post mortem examination in 1940 showed a fairly extensive fibrosis with many nodules There were small scattered foci of [illegible]
logical sections show [illegible]
of considerable imp[illegible]
not as constant as it [illegible]
is no record of the [illegible]
the furnace lining at [illegible]
he had to handle gar[illegible]
a week

5 MALE, emplo[illegible]
layer. His X[illegible]
(probably sili[illegible]
new growth)
tuberculosis

6 [illegible]

[illegible] that these men were still [illegible] not sought medical advice

1 MALE, aged 38 years whole-time dismantler of open hearth (Siemens) furnaces for the past 6 years and interm[illegible]
relevant in the [illegible]
cough with slig[illegible]

[illegible]

3 MALE, aged 51 yea[illegible]
on dismantling and the r[illegible] furnace linings No symptoms, barrel shaped chest with poor expansion (1") No abnormal physical signs except hyperresonance to percussion at the bases X-ray film showed increased linear striation with some reticulation No definite evidence of silicosis.

4 MALE, aged 35 years 14 [illegible]
viously a bricklayer on building [illegible]
toration or shortness of breath [illegible]
some increase of linear striation [illegible] No evidence of silicosis

5 MALE, aged 57 years – dismantler of Siemens furnaces for 8 years Previously 18 years a coalminer and furnace attendant for 14 years. No symptoms; no abnormal physical signs, X-ray film showed some increased linear striation but no reticulation or nodulation No evidence of silicosis

6 MALE, aged 40 years – bricklayer for 19 years of which 13 spent on dismantling and rebuilding Siemens furnaces Before that a clerk for 8 years Slight cough, but no other symptoms Only abnormal physical sign is the presence of *post-tussic crepitations in the right axilla and right base* X-ray film showed reticulation both lower zones, but no nodulation No definite evidence of silicosis

[illegible]

8 MALE, aged 32 years – furnace bricklayer for 15 years, 10 of which spent [illegible] iously an office boy. [illegible] rmal physical signs. [illegible] mphysematous areas.

Of the 8 cases, 1 had silicosis and tuberculosis, 2 had early silicosis and the remaining 5 had X-ray evidence of dust inhalation

9 Another case from this factory came to the notice of the Silicosis Medical Board in 1945

MALE, aged 42 years – furnace bricklayer for 20 years Attended hospital complaining of swelling of ankles for 2 weeks and of cough and dyspnoea for 2 years Found to have essential hypertension (B P. 200/140) and silicosis (X ray nodulation)

MISCELLANEOUS FOUNDRY OCCUPATIONS

(i) *Electric arc welder and occasional steel fettler.* MALE, aged 37 years, [illegible]

(ii) *[illegible] welder in steel fettling shop* In the pathology section (q v) [illegible] 34½ years as a [illegible] ho-pneumonia

(iii) *Oxyacetylene burner in steel fettling shop.* MALE, aged 44 years who [illegible]

[illegible] to be highly active in producing silicosis [illegible] iron moulding when a parting powder containing free silica is used

MALE, aged 49 years, who had been a coremaker for 33 years, i e, most of his working life He became ill with chest symptoms and he died from silicosis and tuberculosis The diagnosis was confirmed by histological examination

(v) *"Mucker out" of steel castings* The job of "mucker out" of steel castings is comparable with the "knock out" (or "shake out" in the U S A) It is unusual to find a man who has remained at the job for most of his working

MALE, aged 48 years –

nosis of early silicosis

(vi) *Labourer (pitman) in an iron foundry* MALE, aged 42 years – for 20 years a labourer in the pipe pits of an iron foundry where drain pipes are made. Apart from 2 years work on coal screens and 2 years work on the roads of a

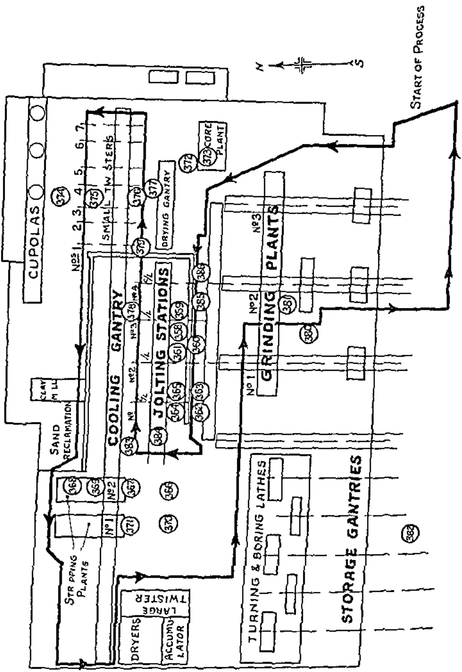


FIG 47 LAYOUT OF IRON FOUNDRY W SAND SPUN PIPE PLANT RINGED FIGURES ARE THE REFERENCE NUMBERS OF THE THERMAL PRECIPITATOR DUST SAMPLES AT THE POSITIONS WHERE THEY WERE TAKEN ARROWS INDICATE THE SEQUENCE OF OPERATIONS IN THE MANUFACTURE OF SAND SPUN PIPES

CHAPTER VII

DUST SAMPLING INVESTIGATIONS IN AN ENGLISH IRON FOUNDRY

BY KENNETH L GOODALL

With a note on Clinical and X ray Examinations
BY A I G McLAUGHLIN

Introduction

This chapter records the results of a study of the atmospheric dust conditions which existed in recent years in an iron foundry in the Midlands For reasons already given in Chap III (page 27) this foundry which will subsequently be designated as Iron Foundry W was not among the foundries whose full medical investigation forms the subject of this book though a limited amount of clinical and X ray data relating to its workers is available and is added as a note at the end of this chapter Since however Foundry W was a large concern representative of its kind the dust surveys made in it will serve roughly to indicate the nature and amount of the dust clouds being breathed by workers in English iron foundries until such time as a fuller picture can be made available from the detailed studies now in progress by other workers in iron foundries appearing in the list of foundries A to T referred to in Chapter III

The information on dust conditions in Iron Foundry W is limited to dust count and size distribution data obtained from thermal precipitator samples of working atmospheric conditions throughout the foundry This large foundry was engaged solely in the manufacture of sand spun iron pipes and thermal precipitator dust samples were taken in connection with the various processes and operations which were considered to be especially giving rise to dust clouds The silicosis risk to the workers in this foundry arose from the preparation, use and removal after use of a moulding sand in the process of pipe spinning, the moulding sand composition being —

75% Leighton Buzzard Sand (containing 96% free silica SiO_2)
15% Scotch Rock (containing 76% free silica and 14% clay)
10% Clay Wash of specific gravity 1 6

As far as possible dust measurements were made at all stages in the process of pipe spinning where the sand could contribute to the dust cloud being breathed by the workers The process of making iron pipes by the sand spun process involved at the time the initial dust survey was made very dusty working conditions and the problem of controlling them was a very intractable one Subsequently however by redesign of parts of the plant alterations in methods of working and a fuller use of plant enclosure and application of exhaust draught a great improvement in working conditions was effected and a second survey whose results will also be recorded gives a measure of this improvement

DESCRIPTION OF THE FOUNDRY PROCESSES

The plant was designed for the production of sand spun pipes varying in size from 4 to 24" diameter with a laying length in all cases of 16 feet Iron pipe casting is normally done by pouring the molten iron into standing moulds A sand spun pipe however is produced instead in a rapidly revolving sand lined mould called a flask This centrifugal casting of the iron is known as spinning

The axis of the flask is horizontal and the molten iron is run in at one end to form a lining of even thickness over the whole of the interior surface of the mould This lining on solidification and cooling is the sand spun pipe The method ensures rapid production of a very true pipe of uniform metal The pipes as normally
increased tensile s
thinner than Brit
manufacture of sand moulds and of iron pipes and production took place in one large room of approximate dimensions 420 long x 250 wide x 55 high In the process of manufacture the following foundry sections were involved and their location is shown on the plan of the works in Figure 47

Core Making Section The socket cores which were inserted in the mould to

These latter
the overhead
and then jolt
beaten firm with a flat board The cores were then removed to nearby ovens where they were baked out blacked, and delivered to the spinners The mixing and baking out gave rise to no appreciable dust because of the oily nature of the material processed, but there was some likelihood of a small amount of dust being created by the jolting process itself

Mould Making Stations – the Jolters In this section – the dustiest of all – the sand moulds were made in the flasks There were four of these stations, Nos 2, 3 and 4, making use of pneumatic jolters each capable of handling loads up to 12 tons in weight while at No 1, pneumatic rammers were used instead of jolters In the case of the jolter stations, the socket patterns were carried by the jolter tables themselves and in the remaining case by a rotating table The socket patterns were also used to centre the flasks and the lower end of the body patterns in relation to each other, in addition to their primary duties The body patterns were raised and lowered by means of electric winches and when the patterns were in position in the flasks they were centred at the top end by means of the sand hopper castings these latter being used as guides for the sand when entering the flasks

spun to form the pipe To pack this sand annulus tight and firm so that it would retain its shape and bonded strength for the spinning process the flasks after filling were given approximately 200 jolts, before the sand hopper was removed and the groove for the bead made This jolting as might be expected,

patterns and the internal surface of the flask when this was being initially lowered into position prior to jolting The air in this passage under the jolters was thick with dust continuously The conditions will be further described in connection with the dust counts taken

At No 1 station the sand was fed in continuously while the flask revolved,

each station

Mould Drying Section Here all moulds were skin dried immediately before their transfer to the spinners This operation was carried out by means of high velocity coke oven gas jets which injected a large quantity of heated air into the moulds There was no special source of sand dust associated with this operation.

Pipe Spinning or Casting Section There were seven spinners, for dealing with pipes of from 4" to 12" in diameter Their function was to rotate the flasks containing their sand lining, at such a speed as to subject the molten iron, when poured in, to a centrifugal force of at least seventy five times that of gravity Each machine consisted essentially of a framework containing four rollers, two of which were driven and two idle The flask was transferred by

solidified in position inside the flasks, and the whole process was not responsible for any special degree of dustiness

The Cooling Gantry The spun pipes were rolled from the spinners on to this gantry to cool slowly prior to stripping Initially bright red as they left the spinners they gradually cooled on the gantry to a temperature at which they could take no harm when stripped Each pipe remained cooling in its mould on this gantry for at least an hour before being stripped These cooling pipes

to much fume

the dust laden air was exhausted into the main dust extraction system The

second operation consisted of the removal of the pipe by means of two hydraulic rams, which pushed the pipe from the flask on to a transfer bogie waiting to receive it. With the ejected pipes came out the remainder of the hot

disseminated into the general air of the shop At times however, clouds of *dust belched out from the canvas curtains of the blow boxes*, and when this occurred the exhaust arrangements exerted very little control over the dust

Sand Preparation Plant About 95% of the used sand was re-used for mould

Batches of this sand were fed

was rotary

the sand,

grinding a jet of water was squirted continuously into the pipe The pipes after leaving this section were then ready for final testing and coating with hot tar solution

Dust Samples taken and their Evaluation A series of 29 thermal precipitator dust samples was taken in connection with the various processes enumerated

in the approxi-

processes

id similar

dust samples from foundry atmospheres presents peculiar difficulties which

the same extent in other industries and which

nineral dust con-

an industry and

s are incinerated

smaller particles to be seen, as diffraction circles Normally in most industrial air-borne dust samples so obtained and treated some portion of the atmospheric pollution remains behind and since it is mostly under $0\ 5\mu$, slightly

foundries however, the background atmospheric particle pollution frequently is out of all proportion greater than the dust created by the individual process

them, especially in the lower size ranges Consequently the margin for error in evaluating the dust counts for processes in iron and steel foundries is much increased It must be realised that the thermal precipitator takes an approxi-

were —

(a) Fly ash from metal cupolas, particularly when being fed or when ash and slag is being removed

(b) Dust from the work of crane men emptying dusty pig iron ingots from trucks on to stock heaps

(c) Fumes from ladles of molten iron or steel

(d) Fumes from the casting of molten iron or steel into flasks or moulds

(e) Fumes from coated electrodes in arc welding work and from oxy-acetylene cutting work

(f) Oily haze from core stoving plant, where sand cores bonded with linseed oil and molasses are stoved

(g) Oil mist from various hydraulic blow down valves

(h) Oily fumes arising from pipe spinning and cooling gantries where molten and red hot iron is in contact with oily sand linings, and from the work of smashing out burning oil bonded sand cores from spun pipes

(i) Atmospheric pollution from batteries of large gas jets in mould drying sections or from wood, coke or coal fires used for drying out moulds

(j) Fumes from annealing oven work

(k) Smoke from various braziers

(l) Dust from floor sweeping, which takes place from time to time

Pollution from such sources is often superimposed on to the abnormally heavy atmospheric pollution characteristic of some of our major industrial towns, such as Sheffield, where steel foundry X, dealt with in the subsequent

Though present in the size range up to about 0 8μ the majority of the pollution

particles were considered to be those not clearly of a natural mineral nature and originating from the specific process under test If doubt was felt as to whether a particle was a pollution particle or not it was counted As an example it may be mentioned that Record 369 (Atmosphere breathed by No 2 Blow

to the relative dustiness of the foundry processes concerned

Nevertheless one is left with the firm impression on account of the doubts and difficulties arising in the evaluation of the samples and of the time and labour consumed in this work and in obtaining such samples, that dust counts in iron foundries have a very limited value and that future workers in this field would be well advised, at least in the first instance, to abandon dust counts in favour of long period gravimetric samples of the air-borne dust under 5μ These gravimetric samples, besides providing mass concentration estimations to which the relatively tiny pollution particles would make only their appropriately small contribution, would furnish material for X ray diffraction studies and for chemical or micro-chemical analyses (especially for free and total silica)
the four
be asses

Table XLV in the sequence of the manufacturing operations

TABLE XLV. THERMAL PRECIPITATOR DUST COUNTS IN IRON FOUNDRY W (SAND SPUN PIPE PLANT)

Test No	Foundry Section	Process Tested	Particles per cc	Size Distribution	Remarks
372 3 5 p m 4 p m	Core making section	General atmosphere adjacent to core making plant	395	Median Size 0 4μ 86% over 0 2μ (14% less) 37% over 0 5μ (63% less) 14% over 1μ (86% less) 4% over 2μ (96% less) 0 2% over 5μ (99 8% less)	Test spot lay between core making and spinning plants, near empty gantry No work proceeding anywhere in immediate neighbourhood of this test No core making being done for last 30 mins. of test Test included period occupied by test 373 following Boy swept core making plant floor during test
373 3 p m 3 29 p m	—ditto	Breathing level of boy core maker working middle one of 3 core making moulds.	740	Median Size 0 3μ 75% over 0 2μ (25% less) 27% over 0 5μ (73% less) 11% over 1μ (89% less) 6% over 2μ (94% less) 0 2% over 5μ (99 8% less)	Two outside core making moulds not working. No visible dust produced Sand cores were bonded with linseed oil and molasses Oiled sand fell from bunker into 2 moulds was rubbed in by hand, and jolted 150 times Top layer of sand on moulds then beaten with flat board after which mould table was inverted over the flat board to remove cores for sending away to baking-out oven Much oil mist about from hydraulic blow down valves and adjacent core stoving ovens

chapter, was located, and results in a working atmosphere visibly thick with haze, smoke and fume, and in considerable dust deposits on girders and other settling places

Though present in the size range up to about 0 8μ the majority of the pollution particles on the present series of thermal precipitator records were below 0 3μ which was also the approximate limit of resolution with the 2 mm oil immersion apochromatic objective of N A 1 34 used, when served by a condenser of similar numerical aperture, using blue-green light, and in relation to the tech

particles were considered to be those not clearly of a natural mineral nature

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\s an example

No 2 Blow

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ed in

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the limitations of the method above enumerated, of the mineral air borne dust concentrations to be associated with the specific processes tested All slides having been evaluated on the same basis, a very rough guide is thus furnished to the relative dustiness of the foundry processes concerned

would be well advised at least in the first instance, to abandon dust counts in favour of long period gravimetric samples of the air borne dust under 5μ These gravimetric samples besides providing mass concentration estimations to which the relatively tiny pollution particles would make only their appropriately small contribution, would furnish material for X ray diffraction studies and for chemical or micro-chemical analyses (especially for free and total silica) of

the four ild

be asses

The thermal precipitator samples obtained in the present investigation were incinerated for 30 minutes at approximately 450°C to remove as much atmospheric pollution in the form of soot, organic matter, etc, as possible *The* counts made on these 29 samples on the basis referred to above are given in Table XLV in the sequence of the manufacturing operations

TABLE XLV THERMAL PRECIPITATOR *DUST COUNTS* IN IRON FOUNDRY W (SAND SPUN PIPE PLANT)

Test No	Foundry Section	Process Tested	Particles per cc	Size Distribution	Remarks
372 *3 5 p m 4 p m*	Core making section	General atmosphere adjacent to core making plant	395	Median Size 0 4μ 86% over 0 2μ (14% less) 37% over 0 5μ (63% less) 14% over 1μ (86% less) 4% over 2μ (96% less) 0 2% over 5μ (99 8% less)	Test spot lay between core making and spinning plants, near empty gantry No work proceeding anywhere in immediate neighbourhood of this test No core making being done for last 30 mins of test *Test included period occupied by test 373 following* Boy swept core making plant floor during test
373 3 p m - 3 29 p m	—ditto—	Breathing level of boy core maker working middle one of 3 core making moulds	740	Median Size 0 3μ 75% over 0 2μ (25% less) 27% over 0 5μ (73% less) 11% over 1μ (89% less) 6% over 2μ (94% less) 0 2% over 5μ (99 8% less)	Two outside core making moulds not working No visible dust produced Sand cores were bonded with linseed oil and molasses Oiled sand fell from bunker into 2 moulds, was rubbed in *by hand, and jolted 150 times* Top layer of sand on moulds then beaten with flat board after which mould table was inverted over the flat board to remove cores for sending away to baking-out oven Much oil mist about from hydraulic blow down valves and adjacent core stoving ovens

TABLE XLV—*continued*

Test No	Foundry Section	Process Tested	Particles per cc	Size Distribution	Remarks
358 3 6 p m – 4 4 p m	Pneumatic jolting system of mould making Top plat form	General atmosphere on top jolter platform 10 ft behind worker on No 3 jolter tested in next test	610	Median Size 0 25μ 60% over 0 2μ (40% less) 27% over 0 5μ (73% less) 13% over 1μ (87% less) 6% over 2μ (94% less) 1 5% over 5μ (98 5% less)	—
359 3 17 p m – 3 57 p m	—ditto—	Breathing level of worker at No 3 jolter on top platform making moulds	780	Median Size 0 65μ 79% over 0 2μ (21% less) 57% over 0 5μ (43% less) 39% over 1μ (61% less) 16% over 2μ (84% less) 1 5% over 5μ (98 5% less)	Workers job was to (1) bring flask into vertical position on the gantry below, (2) lower body pattern *into flask after first* blowing all dust off bearing surfaces, (3) feed in sand to annulus between flask and body pattern, (4) when flask full jolt 200 times, (5) withdraw body pattern, (6) blackwash inside surface of mould with flush of powdered coke bonded with clay wash, (7) lower mould on tilting table to drying gantry *This cycle of operations lasted roughly 8* minutes and was repeated more or less continuously Dust arose particularly from (4) and (3) Also from assistant wire brushing steel filling caps placed over flask mouth during filling, from banging an end cap on to mould prior to withdrawing body pattern, and from vibration of platform during the jolting No 1 rammer, and Nos 2 and 3 jolters at work No 4 not

TABLE XLV—*continued*

Test No	Foundry Section	Process Tested	Particles per cc	Size Distribution	Remarks
360 11 45 a m - 12 47 p m	Pneumatic jolting system of mould making Underjolters	General atmosphere in working chamber underneath and between Nos 2 and 3 pneumatic jolters, during run of following test	1,820	*Median Size 0 8μ* 86% over 0.2μ (14% less) 64% over 0 5μ (36% less) 42% over 1μ (58% less) 21% over 2μ (79% less) 3% over 5μ (97% less)	Thermal precipitator 12 away from each jolter and at back of the room behind the brick pier separating Nos 2 and 3 jolters No 2 jolter at work continuously and No 3 jolter at intervals during test
361 11 55 a m 12 46 p m	—ditto—	Breathing level of worker on bottom of No 2 jolter	2 800	Median Size 0 7μ 81% over 0 2μ (19% less) 59% over 0 5μ (41% less) 38% over 1μ (62% less) 19% over 2μ (81% less) 4% over 5μ (96% less)	Work consisted of the compressed air jet cleaning of inside bottoms of flasks and of spigot base on hydraulic jolting table on to which they descended, inserting keys to hold flask on to jolting table and removing same No exhaust arrangements provided An extremely heavy dust cloud arose from (1) the jolting, (2) the neighbouring jolter, (3) the compressed air jet cleaning of the spigot end and inside of flasks, (4) wiping over of spigot end and table and flask internal surface with dry duster, (5) the dust shaken down from the top jolter platform above The air was thick with dust in this working chamber A water spray was used on the flask whilst jolting was in progress but it was of little use for suppressing the dust
385 10 46 a m - 12 7 p m	—ditto—	*General atmosphere in* working chamber underneath and between Nos 3 and 4 pneumatic jolters during run of following test	1,140	Median Size 0.4μ 72% over 0 2μ (28% less) 41% over 0 5μ (59% less) 24% over 1μ (76% less) 13% over 2μ (87% less) 3% over 5μ (97% less)	Thermal precipitator 12 away from each jolter and in front of the brick pier separating Nos 3 and 4 jolters No 4 jolter working No 3 not

TABLE XLV—*continued*

Test No	Foundry Section	Process Tested	Particles per cc	Size Distribution	Remarks
386 11 a m – 12 5 p m	*Pneumatic jolting system of mould making Under jolters*	*Breathing level of worker on bottom of No 4 jolter 3 body patterns and 3 flasks in use on this large machine*	*1,230*	*Median Size 0 35μ* 68% over 0 2μ (32% less) 35% over 0 5μ (65% less) 19% over 1μ (81% less) 8% over 2μ (92% less) 1% over 5μ (99% less)	under al type s jolter is jolter id any ements bottom open placed htly in he dust e up to er men i flask y little tted. A ew past , down 2 and 1, under- he least is same likely to the dust w past
364 12 noon – 1 5 p m	Pneumatic ramming system of mould making Top platform	General atmosphere on top platform 12 ft behind worker on No 1 rammer tested in next test	475	Median Size 0 25μ 63% over 0 2μ (37% less) 25% over 0 5μ (75% less) 10% over 1μ (90% less) 3% over 2μ (97% less) Nil over 5μ (100% less)	—

TABLE XLV—*continued.*

Test No	Foundry Section	Process Tested	Particles per cc	Size Distribution	Remarks
365 12.10 p.m. – 1 6 p.m.	—ditto—	Breathing level of worker attending No 1 pneumatic rammer on top platform, making moulds	620	Median Size 0 35μ 70% over 0 2μ (30% less) 41% over 0.5μ (59% less) 23% over 1μ (77% less) 12% over 2μ (88% less) 0 6% over 5μ (99 4% less)	

TABLE XLV—*continued.*

Test No	Foundry Section	Process Tested	Particles per cc.	Size Distribution	Remarks
362 2 48 p m – 3 52 p m	Pneumatic ramming system of mould making Under rammers	General atmosphere of working chamber underneath No 1 pneumatic rammer during run of following test	980	Median Size 0 3μ 66% over 0 2μ (34% less) 35% over 0 5μ (65% less) 18% over 1μ (82% less) 8% over 2μ (92% less) 1 5% over 5μ (98 5% less)	Much of the dust in this chamber was blown by draughts from the Nos 2 and 3 jolters working *adjacent*
363 2 51 p m – 3 51 p m	—ditto—	*Breathing level of worker* on bottom of No 1 pneumatic rammer	1,250	*Median Size* 0 35μ 70% over 0 2μ (30% less) 40% over 0 5μ (60% less) 23% over 1μ (77% less) 10% over 2μ (90% less) 1% over 5μ (99% less)	The sand annulus in this form of mould making was pneumatically rammed in the annulus between flask and body pattern whilst the flask slowly rotated Much less dust created this way than by the jolting method Large pipe moulds only made this way (12 – 18) Worker's job was to see flask correctly lowered on to rotating table He also blew off dust from the retaining spigot on *rotating table and* from flask internal surfaces before lowering flask into position, using compressed air jet Apart from this dust much dust was blown by draughts past neighbouring jolters into the working chamber, and more dust was thrown off when flask began to rotate (partly suppressed by a water spray) Other dust was *disturbed and fell* from above when flasks were dropped by the crane on to tables above Normally, one pipe mould was made every 15 minutes *but due to delay of* 25 minutes through flask shortage shortly after test began, only 3 moulds made during this test Man swept floor during test

TABLE XLV—*continued*

Test No	Foundry Section	Process Tested	Particles per cc	Size Distribution	Remarks
383 2 58 p m 4 4 p m	In roof above jolters at crane men s level	General atmosphere at floor level, in walking way down middle of shop between pneumatic rammer No 1 *and pipe cooling gantry* Taken same time as next test	520	Median Size 0 35μ 77% over 0 2μ (23% less) 37% over 0 5μ (63% less) 21% over 1μ (79% less) 11% *over* 2μ (89% less) 1% over 5μ (99% less)	fust clouds were being nstrument A certain hot core dust rolled ends of flasks being wn adjacent cooling trippers This count with the next one a rough idea of the tribution of dust in h shop
384 3 9 p m 4 7 p m	—ditto—	At breathing level on working platform 40 above floor level above jolter and rammer sand feed bunkers	850	Median Size 0 3μ 75% over 0 2μ (25% less) 30% over 0 5μ (70% less) 14% over 1μ (86% less) 5% over 2μ (95% less) 0 5% over 5μ (99 5% less)	int on this platform ioulding sand from elt coming from sand l recovery plant, into rage bunkers over the d l rammer No dusty instrument The sand itform only fell from oand down guides into s, and, being damp, practically no dust is at the same level as en s cabs and should of the amount of dust y these workers The height must nearly all processes at or near el The nearest large dust to the test point at the jolters below, st rose up the front dge 6 from the ther- tator

TABLE XLV—*continued*

Test No	Foundry Section	Process Tested	Particles per cc	Size Distribution	Remarks
377 1 7 p m – 2 47 p m	Mould heating and drying section	Breathing level of attendant controlling high pressure coke oven gas jets by side of mould drying gantry	510	Median Size 0.3 μ 69% over 0.2 μ (31% less) 31% over 0.5 μ (69% less) 17% over 1 μ (83% less) 9% over 2 μ (91% less) 2% over 5 μ (98% less)	Instrument placed half-way along the 8 gas jets and *between the* middle two Should represent almost exactly what attendant breathes, his work being only to attend the jets and direct them *into the filled and* blacked moulds on the gantry, to dry them out before they are put on the spinners No special source of dust near test position Dust from the cupola and spinning section drifted over the thermal precipitator.
374 10 33 a m – 12 43 p m	Pipe spinning section	General atmosphere in open space half-way between cupola and Nos 3 and 4 spinners.	270	Median Size 0.3 μ 75% over 0.2 μ (25% less) 26% over 0.5 μ (74% less) 6% over 1 μ (94% less) 1.3% over 2 μ (98.7% less) 0.1% over 5 μ (99.9% less)	Test position *15′ from spinner* inlets The cupola house had open sides and a strong breeze always blew from the cupolas towards the spinners. A low count would thus be expected at this position, with increasing values for the next two tests Most of dust appeared to blow in from man shovelling cupola slag *into a bin, and from the* emptying of dusty pig iron trucks on to a stock heap outside the cupolas Fume and smoke also arose from molten iron ladles carried by crane from cupola to spinners.

TABLE XLV—*continued*

Test No	Foundry Section	Process Tested	Particles per cc	Size Distribution	Remarks
375 10.22 a m 11 38 a m	Ditto	General atmosphere at breathing level half way between feed inlets to Nos 3 and 4 spinners	470	Median Size 0 3μ 70% over 0 2μ 33% over 0 5μ (30% less) 20% over 1μ (67% less) 11% over 2μ (80% less) 2% over 5μ (89% less) (98% less)	Test as near as possible to where spinner attendant worked in removing drossings from molten iron charge tilting ladle full of molten iron into spinners cleaning out ladle guide channel and flushing same with blacking Test should represent amount of dust breathed by spinner attendants who had considerable idle periods whilst pipes were being spun In addition to dust from cupolas as above much fume and oily mist etc arose from molten iron ladles hot blacking on ladles and from cooling moulds when spun
376 11 55 a m 1 8 p m	—ditto—	General atmosphere at breathing level on core side of spinners (opposite side to the ladle end) half way between Nos 3 and 4 spinners	470	Median Size 0 3μ 70% over 0 2μ (30% less) 21% over 0 5μ (79% less) 6% over 1μ (94% less) 2% over 2μ (98% less) Nil% over 5μ (100% less)	Count should represent dust concentration breathed by spinner attendants on this side of spinners whose job was to preheat mould with a gas jet feed empty flasks from gantry into spinners operate controls of spinners, put sand core into flask end lower safety hood into position, eject spun flask and remove end plate No special dust clouds made here Same general dust sources as test 375

TABLE XLV—*continued*

Test No	Foundry Section	Process Tested	Particles per cc	Size Distribution	Remarks
379 3 12 p m 4 7 p m	Mould cooling gantry	General atmosphere between mould cooling gantry and mould drying gantry during run of following test	640	Median Size 0 3μ 73% over 0 2μ (27% less) 31% over 0 5μ (69% less) 16% over 1μ (84% less) 9% over 2μ (91% less) 2% over 5μ (98% less)	Position of test midway across main central walking way down shop, at windward end
378 2 55 p m – 4 5 p m	—ditto—	*General atmosphere* 2 off floor, underneath cored end of rolling spun flasks as they came off the spinners and rolled down the gantry to the strippers	300	Median Size 0 3μ 67% over 0 2μ (33% less) 27% over 0 5μ (73% less) 15% over 1μ (85% less) 9% over 2μ (91% less) 1% over 5μ (99% less)	
366 3 *p m* – 3 57 *p m*	Stripping plant	General atmosphere 12 away from worker tested in next test towards middle of walking way between strippers and jolters	350	Median Size 0 3μ 68% over 0 2μ (32% less) 28% over 0 5μ (72% less) 14% over 1μ (86% less) 6 5% over 2μ (93 5% less) 0 3% over5μ (99 7% less)	

TABLE XLV—*continued*

Test No	Foundry Section	Process Tested	Particles per cc	Size Distribution	Remarks
367 3 8 p m 3 56 p m	ditto—	Breathing level of stripper attendant at small pipe stripping plant	420	Median Size 0 35μ 76% over 0 2μ 38% over 0 5μ (24% less) 26% over 1μ (62% less) 17% over 2μ (74% less) 3% over 5μ (83% less) (97% less)	Work at this plant consisted in flask containing the cooled spun pipe being rolled out of the blow box on to a table under a very large exhausted baker s oven type hood Pipe was then pushed out of flask by a hydraulic ram The man tested beat off the annular crust of moulded sand with a crowbar as the pipe emerged The sand slabs fell into a pit with a grid floor and he knocked the lumps through the grids (into an elevator system) if they did not fall through Both these jobs were very dusty When man was working under the hood or near it the dust generated and exhausted upwards into hood top tended to pass man s breathing level on its way into exhaust system. The man did not spend all his time under or near the hood however as he had to wait for flasks. Also not all the sand needed crowbarring off the pipe being pushed out,—a lot fell off naturally When the pipe was pushed out the flask was up ended on its carriage bed and all dust remaining in flask fell out on to the dust pit grids causing a considerable cloud Dust sometimes belched out from the blow box adjacent Further dust fell from the exhaust hood ledges

TABLE XLV—*continued*

Test No	Foundry Section	Process Tested	Particles per cc	Size Distribution	Remarks
370 11.51 a.m. – 12.47 p.m.	*Stripping plant*	*General atmosphere on mid* line of shop adjacent to stripping plants Equidistant from Nos 1 and 2 stripping plants and taken during run of following test	850	*Median Size 0.3µ* 70% over 0.2µ (30% less) 27% over 0.5µ (73% less) 11% over 1µ (89% less) 5% over 2µ (95% less) 0.5% over 5µ (99.5% less)	—
371 11.55 a.m. – 12.46 p.m.	—ditto—	Breathing level of stripper labourer serving both Nos 1 and 2 stripping plants (up to, and over, 12 pipes) during change of shifts	670	Median Size 0.4µ 68% over 0.2µ (32% less) 45% over 0.5µ (55% less) 35% over 1µ (65% less) 25% over 2µ (75% less) 9% over 5µ (91% less)	Worker's job was to smash off caked sand annulus from emerging pipes, exactly as for test 367 *q.v.* Dust arose from this crow-*barring work, from the up-ending* of the flasks after ejection of pipes, to remove all remaining sand from them, from crowbarring of lumps of sand through grid floor of pit to elevator, from scraping remaining dust out of ends of flasks waiting between strippers to be removed by overhead crane for re-use, from rodding of these flasks into position for crane to pick them up, from large dust clouds belching out of blow boxes canvas openings occasionally, and from one flask rolling out of the blow box banging into another waiting on the stripper table
368 10.27 a.m. – 11.23 a.m.	—ditto—	General atmosphere 14' away from No 2 Blow Box and Stripping Plant, during run of following test	410	Median Size 0.4µ 73% over 0.2µ (27% less) 42% over 0.5µ (58% less) 27% over 1µ (73% less) 16% over 2µ (84% less) 6% over 5µ (94% less)	Test *position was in rear of* stripping plant and between pipe ejector hydraulic rams and blow box compressed air rods, in the *walking way* Man swept floor during test, near test position, for a few minutes

TABLE XLV—*continued*

Test No	Foundry Section	Process Tested	Particles per cc	Size Distribution	Remarks
369 10 72 a m 11 20 a m	—ditto—	Breathing level of No 2 Blow Box attendant at stripping plant for pipes up to 12 diameter	1 600	Median Size 0 3μ 76% over 0 2μ (24% less) 30% over 0 5μ (70% less) 12 5% over 1μ (87 5% less) 6% over 2μ (94% less) 1% over 5μ (99% less)	control electric compressed air and out of pipes ping in the blow sand annulus in as blown out in facilitate subse- f the pipes from rams adjacent st came from the jacent ramming from the blow rolled out on to through loose hich on rising eavy dust cloud haust hood over nt The exhaust at all and con louds bellowed and the worker were also slight side and top of jacent to where nsiderable quan caped from the ide flap Some n also came no adjacent sand t By no means sed by the ram olled by the ex l some escaped ar the worker second half of n also operated pe ejector rams average of what the two workers n this side of the heavily polluted Counting every nits of visibility particles per cc 16μ

TABLE XLV—*continued.*

Test No	Foundry Section	Process Tested	Particles per cc	Size Distribution	Remarks
380 10 32 a m - 12 12 p m	Pipe grinding shop	General atmosphere of pipe grinding shop half-way between grinder tested in following test and shop wall Taken during run of following test	435	Median Size 0 35μ 75% over 0 2μ (25% less) 34% over 0 5μ (66% less) 17% over 1μ (83% less) 6% over 2μ (94% less) 0 3% over 5μ (99 7% less)	No dusty work in immediate vicinity of test point. Instrument 20′ away from worker tested in following test
381 10 39 *a m* 11 48 *a m*	—ditto—	Breathing level of internal pipe grinding worker on No 2 grinder	500	Median Size 0 3μ 73% over 0 2μ (27% less) 33% over 0 5μ (67% less) 15% over 1μ (85% less) 5% over 2μ (95% less) 0 6% over 5μ (99 4% less)	The large pipes were slowly rotated horizontally and a long shafted abrasive wheel was slowly moved into the rotating pipe and ground its internal surface up to half-way along the pipe length A worker at the other end of the pipe similarly ground *the other half. A jet of water was* squirted continuously into the pipe (from the end near the test position) whilst grinding proceeded, to damp down the dust The worker sat on the encased shaft of the grinding wheel while it was pushed backwards and forwards. One *pipe took about* 20 minutes to grind Two men worked side by side, on two pipes also side by side Workers kept a minimum of 3′ away from the open ends of the pipe, from which a dusty mist was constantly issuing Most dust came out as the dry pipes, very dusty inside, were first rotated. The dust evolution decreased considerably when the internal surfaces became *thoroughly wetted* 3 pipes were ground during the test, and one pipe was reground

TABLE XLV—*concluded*

Test No		Foundry Section	Process Tested	Particles per cc	Size Distribution	Remarks
382 12.6 p.m	2 35 p m	Outside sand spun pipe plant	Control sample of the air outside the sand spun pipe plant in the open 90 away from the side wall of the plant on the leeward side	165	Median Size 0 5μ 80% over 0 2μ (20% less) 50% over 0 5μ (50% less) 30% over 1μ (70% less) 15% over 2μ (85% less) 2% over 5μ (98% less)	The sand cloud from the vent pipe on the roof of the sand spun pipe plant was drifting overhead roughly in the direction of the thermal precipitator test position

Discussion of Table XLV dust counts.

The danger of attaching too great a value to this series of dust counts, owing to the difficulties of evaluation, was pointed out in the earlier sections of the report, and is again emphasized However, for what they are worth from a rough comparative point of view the counts are summarised in brief in Table XLVI

TABLE XLVI SUMMARY OF THERMAL PRECIPITATOR DUST COUNTS IN IRON FOUNDRY W (SAND SPUN PIPE PLANT)

Sampling Position	*Particles per cc*	*Median Size*
Core Making Plant		
Worker s breathing level	740	0 3μ
General atmosphere	395	0 4μ
Pneumatic Jolters		
Top platform worker	780	0 65μ
General atmosphere	610	0 25μ
Worker underneath jolters	2 800	0 7μ
General atmosphere	1 820	0 8μ
Worker underneath jolters	1 230	0 35μ
General atmosphere	1 140	0 4μ
Pneumatic Rammers		
Top platform worker	620	0 35μ
General atmosphere	475	0 25μ
Worker underneath rammers	1 250	0 35μ
General atmosphere	980	0 3μ
Jolters and Rammers		
In roof at crane men s level	850	0 3μ
At shop floor level	520	0 35μ
Mould Heating and Drying Section		
Worker s breathing level	510	0 3μ
[illegible]		
[illegible]	420	0 3μ
[illegible]	420	0 3μ
[illegible]	270	0 3μ
Mould Cooling Gantry		
2 off floor under rolling flasks	300	0 3μ
General atmosphere	640	0 3μ
Stripping Plant		
Worker s breathing level	420	0 35μ
General atmosphere	350	0 3μ
Worker s breathing level	670	0 4μ
General atmosphere	850	0 3μ
No 2 Blow Box worker s breathing level	1 600	0 3μ
General atmosphere	410	0 4μ
Pipe Grinding Plant		
Pipe grinder s breathing level	500	0 3μ
General atmosphere	435	0 35μ
Outside Control Sample		
Outside plant General atmosphere	165	0 5μ

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general atmosphe

The general conclusion from the evidence provided by the dust sampling investigations and from the medical investigation made in the
A. I G McLaughlin was that
pipe plant whi
workers

tion of further dust suppression measures and their effect on the working atmosphere Eventually the following remedial measures were put into operation —

(a) Pneumatic ramming was substituted for jolting in the lining of flasks at

all four mould making stations, thus eliminating a major source of dust creation and dissemination.

(b) A system of fine water sprays was fitted at each ramming station to cool

present in the sand being rammed in The dust carried away by the steam arising from this external water spraying of the flasks was blown away from the upper filling platform by means of fans.

(c) Provision of more complete enclosure of the blow boxes and stripping ... prevention of dust escape at the ... e compressed air blow pipes, and

... of exhausted collecting hoppers for the reception

the foundry ... in the working atmosphere of the ... d series of thermal ... langerous processes ... les microscopically ... *e same reason*, that

... ut in Table XLVIII, ... d furnish a rough

guide to the extent of ...

TABLE XLVII THERMAL PRECIPITATOR DUST COUNTS IN IRON FOUNDRY W (SAND SPUN PIPE PLANT), AFTER ADOPTION OF FURTHER DUST SUPPRESSION MEASURES

Test No	Foundry Section	Process Tested	Particles per cc	Size Distribution	Remarks
504 10.4 a.m. 11.26 a.m.	Pneumatic ramming system of mould making Top platform	General atmosphere on top rammer platform 10' behind worker on No 3 rammer tested in next test	226	Median Size 0.45μ 79% over 0.2μ (21% less) 45% over 0.5μ (55% less) 29% over 1μ (71% less) 15% over 2μ (85% less) 1.5% over 5μ (98.5% less)	Test in same position as for test 358 of previous series, only all jolters now replaced by rammers
505 10.13 a.m. 11.10 a.m.	—ditto—	Breathing level of worker at No 3 rammer on top platform making moulds	295	Median Size 0.4μ 77% over 0.2μ (23% less) 43% over 0.5μ (57% less) 25% over 1μ (75% less) 10% over 2μ (90% less) 1% over 5μ (99% less)	Test in same position as for test 359 of previous series only all jolters now replaced by rammers All four rammers were working for first 15 mins. of test and thereafter only Nos 3 and 4 No 3 was a double flask rammer The cycle of operations in filling the moulds lasted about 12 mins Worker tested was making 9' pipes and his companion 10' pipes
506 11.45 a.m. – 1.28 p.m.	Pneumatic ramming system of mould making Under rammers	General atmosphere in working chamber underneath and between Nos 2 and 3 pneumatic rammers, during run of following test	262	Median Size 0.25μ 65% over 0.2μ (35% less) 25% over 0.5μ (75% less) 16% over 1μ (84% less) 10% over 2μ (90% less) 1% over 5μ (99% less)	Test in same position as for test 360 of previous series only all jolters now replaced by rammers

TABLE XLVII—*continued*

Test No	Foundry Section	Process Tested	Particles per cc	Size Distribution	Remarks
507 12 3 p m 1 26 p m	Pneumatic ramming system of mould making Under rammers	Breathing level of worker on bottom of No 2 pneumatic rammer	277	Median Size 0 25μ 66% over 0 2μ (34% less) 23% over 0 5μ (77% less) 13% over 1μ (87% less) 6% over 2μ (94% less) 1% over 5μ (99% less)	— e position as for test ious series only all eplaced by rammers *rotating* was now ι U tube water spray ol the flask Dustiest w had was to wipe of mould surfaces ndplate was clamped a sand seal for the the sand annulus ly took him about a ry twenty A cycle of vas about 12 mins was somewhat inter *Worker s job* was ng with the controls cleaned the floor w suction cleaning his spare time whil s rotating
512 1 40 p m 2 29 p m	Pneumatic ramming system of mould making Top platform	General atmosphere on top platform 10 behind worker on No 1 pneumatic rammer *tested in next test*	260	Median Size 0 85μ 93% over 0 2μ (7% less) 69% over 0 5μ (31% less) 45% over 1μ (55% less) 21% over 2μ (79% less) 1% over 5μ (99% less)	Test in same position as for test 364 of previous series only all jolters now replaced by rammers
513 1 49 p m 2 53 p m	—ditto—	Breathing level of worker *attending No 1* pneumatic rammer on top platform making moulds	385	Median Size 1 1μ 92% over 0 2μ (8% less) 74% over 0 5μ (26% less) 54% over 1μ (46% less) 29% over 2μ (71% less) 4% over 5μ (96% less)	Test in same position as for test 365 of previous series only all jolters now replaced by rammers

TABLE XLVII—*continued*

Test No	Foundry Section	Process Tested	Particles per cc	Size Distribution	Remarks
516 10 10 a m 11 31 a m	Pneumatic ramming system of mould making Under rammers	General atmosphere of working *chamber underneath* No 1 pneumatic rammer during run of following test	244	Median Size 1 1μ 91% over 0 2μ (9% less) 72% over 0 5μ (28% less) 53% over 1μ (47% less) 31% over 2μ (69% less) 4% over 5μ (96% less)	Test in same position as for test 362 of previous series only all jolters now replaced by rammers A slight draught carried any dust from Nos 4 3 and 2 rammers (all working) towards and past No 1 rammer
515 10 18 a m 11 13 a m	—ditto—	Breathing level of worker on bottom of No 1 pneumatic rammer	253	Median Size 1 0μ 87% over 0 2μ (13% less) 68% over 0 5μ (32% less) 50% over 1μ (50% less) 27% over 2μ (73% less) 2% over 5μ (98% less)	Test in same position *as for test* 363 of previous series only all jolters now replaced by rammers The flask whilst rotating was now water sprayed to cool it This No 1 rammer made large sized pipes
509 3 25 p m 4 51 p m	In roof above pneumatic rammers at crane men s *level*	General atmosphere at floor level in walking way down *middle of shop* between pneumatic rammer No 1 and pipe cooling gantry Taken same time as next test	380	Median Size 0 65μ 85% over 0 2μ (15% less) 56% over 0 5μ (44% less) 40% over 1μ (60% less) 17% over 2μ (83% less) 2% over 5μ (98% less)	Test in same position as for test 383 of previous series
508 3 15 p m 4 40 p m	—ditto—	At *crane men s* breathing level on a working platform 40 above floor level above pneumatic rammer sand feed bunkers	385	Median Size 0 4μ 73% over 0 2μ (27% less) 41% over 0 5μ (59% less) 27% over 1μ (73% less) 14% over 2μ (86% less) 2% over 5μ (98% less)	Test in same position as for test 384 of previous series only all jolters now replaced by pneumatic rammers so there was less dust rising up from down below Otherwise same remarks apply as *for previous test 384*
518 1 46 p m 2 54 p m	Pipe stripping plant	General atmosphere 12 away from worker tested in next test towards middle *of walking way between* strippers and rammers Taken same time as next test	105	Median Size 0 8μ 93% over 0 2μ (7% less) 68% over 0 5μ (32% less) 40% over 1μ (60% less) 21% over 2μ (79% less) 6% over 5μ (94% less)	Test in same position as for test 366 of previous series

TABLE XLVII—*continued*

Test No	Foundry Section	Process Tested	Particles per cc.	Size Distribution	Remarks
517 1 38 p m 2 43 p m	Pipe stripping plant	Breathing level of stripper attendant at small pipe stripping plant (No 2 plant)	200	Median Size 0 9μ 90% over 0 2μ (10% less) 69% over 0 5μ (31% less) 47% over 1μ (53% less) 24% over 2μ (76% less) 3% over 5μ (97% less)	*Test in same position as for test 367 of previous series* Instrument sampling position just under exhaust canopy edge Worker would breathe more dust than recorded by instrument as he had *to go in well under canopy* to crowbar – off the baked sand lining from the flasks after upending and to push the lumps through the grid in the floor 2 small size flasks at once were dealt with at this plant The canopy exhaust had been much *improved since previous series* of tests were made Otherwise same remarks apply as for previous test 367
519 3 28 p m 4 17 p m	—ditto—	Breathing level of stripper attendant at *large pipe* stripping plant (No 1 plant)	83	Median Size 0 95μ 92% over 0 2μ (8% less) 72% over 0 5μ (28% less) 48% over 1μ (52% less) 23% over 2μ (77% less) 3% over 5μ (97% less)	

TABLE XLVII—*concluded*

Test No	Foundry Section	Process Tested	Particles per cc	Size Distribution	Remarks
510 10 28 a m 11 45 a m	—ditto—	General atmosphere 14 from No 2 Blow Box and Stripping Plant during run of following test	136	Median Size 0 7μ 85% over 0 7μ (15% less) 57% over 0 5μ (43% less) 38% over 1μ (62% less) 19% over 2μ (81% less) 3% over 5μ (97% less)	Test in same position as for test 368 of previous series
511 10 25 a m 11 18 a m	—ditto—	Breathing level of No 2 Blow Box attendant at Stripping Plant for pipes up to 12 diameter	120	Median Size 0 85μ 90% over 0 2μ (10% less) 67% over 0 5μ (33% less) 44% over 1μ (56% less) 22% over 2μ (78% less) 4% over 5μ (96% less)	Test in same position as for test 369 of previous series Same remarks apply as for this previous test except that since then the exhaust over the blow box and stripping plant had been greatly improved
514 3 10 p m 5 15 p m	Control sample outside sand spun pipe plant	Control sample of the air outside the sand spun pipe plant in the open 90 away from the side wall of the plant on the leeward side	215	Median Size 1 1μ 95% over 0 2μ (5% less) 78% over 0 5μ (22% less) 54% over 1μ (46% less) 25% over 2μ (75% less) 3% over 5μ (97% less)	Test in same position as for test 382 of previous series The sand cloud from the vent pipe on the roof of the sand spun pipe plant was drifting overhead roughly in the direction of the instrument test position

TABLE XLVII—*continued*

Test No	Foundry Section	Process Tested	Particles per cc	Size Distribution	Remarks
517 1 38 p m 2 43 p m	Pipe stripping plant	Breathing level of stripper attendant at small pipe stripping plant (No 2 plant)	200	Median Size 0 9μ 90% over 0 2μ (10% less) 69% over 0 5μ (31% less) 47% over 1μ (53% less) 24% over 2μ (76% less) 3% over 5μ (97% less)	Test in same position as for test 367 of previous series Instrument sampling position just under exhaust canopy edge Worker would breathe more dust than recorded by instrument as he had to go in well under canopy to crowbar – off the baked sand lining from the flasks, after up ending and to push the lumps through the grid in the floor 2 small size flasks at once were dealt with at this plant The canopy exhaust had been much improved since previous series of tests were made Otherwise same remarks apply as for previous test 367
519 3 28 p m 4 17 p m	—ditto—	Breathing level of stripper attendant at large pipe stripping plant (No 1 plant)	83	Median Size 0 95μ 92% over 0 2μ (8% less) 72% over 0 5μ (28% less) 48% over 1μ (52% less) 23% over 2μ (77% less) 3% over 5μ (97% less)	nt sampling position ›r exhaust canopy edge, ›er would breathe more ın recorded by instru- he had to go in well ınopy as in test 517 noved too much to allow nt to be attached to him ıpes – 15″ and upwards – pped at this plant than plant so the cycle of ıs was much slower of longer cooling time flasks Also only one ıs stripped at a time of these factors the t was exposed to much than the corresponding t the small pipe stripping

TABLE XLVII—*concluded*

Test No	Foundry Section	Process Tested	Particles per cc	Size Distribution	Remarks
510 10 28 a m 11 45 a m	—d tto—	General atmosphere 14 from No 2 Blow Box and Stripping Plant during run of following test	136	Median Size 0 7μ 85% over 0 2μ (15% less) 57% over 0 5μ (43% less) 38% over 1μ (62% less) 19% over 2μ (81% less) 3% over 5μ (97% less)	Test in same position as for test 368 of previous series
511 10 25 a m 11 18 a m	—ditto—	Breathing level of No 2 Blow Box attendant at Str pping Plant for pipes up to 12" diameter	1[illegible]0	Median Size 0 85μ 90% over 0 2μ (10% less) 67% over 0 5μ (33% less) 44% over 1μ (56% less) 22% over 2μ (78% less) 4% over 5μ (96% less)	Test in same position as for test 369 of previous series Same remarks apply as for this previous test except that since then the exhaust over the blow box and stripping plant had been greatly improved
514 3 10 p m – 5 15 p m	Control sample out side sand spun p pe plant	Control sample of the air outside the sand spun pipe plant in the open 90 away from the s de wall of the plant on the leeward side	215	Median Size 1 1μ 95% over 0 2μ (5% less) 78% over 0 5μ (22% less) 54% over 1μ (46% less) 25% over 2μ (75% less) 3% over 5μ (97% less)	Test in same position as for test 382 of previous series The sand cloud from the vent pipe on the roof of the sand spun pipe plant was drifting overhead roughly in the direct on of the instrument test pos tion

TABLE XLVII—*continued.*

Test No	Foundry Section	Process Tested	Particles per cc	Size Distribution	Remarks
517 1 38 p m 2 43 p m	Pipe stripping plant	Breathing level of stripper attendant at small pipe stripping plant (No 2 plant)	200	Median Size 0 9μ 90% over 0 2μ (10% less) 69% over 0 5μ (31% less) 47% over 1μ (53% less) 24% over 2μ (76% less) 3% over 5μ (97% less)	Test in same position as for test 367 of previous series Instrument sampling position just under exhaust canopy edge Worker would breathe more dust than recorded by instrument as he had to go in well under canopy to crowbar – off the baked sand lining from the flasks, after upending, and to push the lumps through the grid in the floor 2 small size flasks at once were dealt with at this plant The canopy exhaust had been much improved since previous series of tests were made Otherwise same remarks apply as for previous test 367
519 3 28 p m 4 17 p m	—ditto—	Breathing level of stripper attendant at large pipe stripping plant (No 1 plant)	83	Median Size 0 95μ 92% over 0 2μ (8% less) 72% over 0 5μ (28% less) 48% over 1μ (52% less) 23% over 2μ (77% less) 3% over 5μ (97% less)	Instrument sampling position just under exhaust canopy edge, so worker would breathe more dust than recorded by instrument, as he had to go in well under canopy, as in test 517 Worker moved too much to allow instrument to be attached to him Larger pipes – 15" and upwards – were stripped at this plant than at No 2 plant, so the cycle of operations was much slower because of longer cooling time of large flasks Also only one flask was stripped at a time Because of these factors the attendant was exposed to much less dust than the corresponding worker at the small pipe stripping plant

TABLE XLVII—*concluded*

Test No	Foundry Section	Process Tested	Particles per cc.	Size Distribution	Remarks
510 10 28 a m – 11 45 a m	—ditto—	General atmosphere 14 from No 2 Blow Box and Stripping Plant during run of following test	136	Median Size 0 7μ 85% over 0 2μ (15% less) 57% over 0 5μ (43% less) 38% over 1μ (62% less) 19% over 2μ (81% less) 3% over 5μ (97% less)	Test in same position as for test 368 of previous series
511 10 25 a m 11 18 a m	—ditto—	Breathing level of No 2 Blow Box attendant at Stripping Plant for pipes up to 12" diameter	120	Median Size 0 85μ 90% over 0 2μ (10% less) 67% over 0 5μ (33% less) 44% over 1μ (56% less) 22% over 2μ (78% less) 4% over 5μ (96% less)	Test in same position as for test 369 of previous series Same remarks apply as for this previous test except that since then the exhaust over the blow box and stripping plant had been greatly improved
514 3 10 p m 5 15 p m	Control sample outside sand spun pipe plant	Control sample of the air outside the sand spun pipe plant in the open 90 away from the side wall of the plant on the leeward side	215	Median Size 1 1μ 95% over 0 2μ (5% less) 78% over 0 5μ (22% less) 54% over 1μ (46% less) 25% over 2μ (75% less) 3% over 5μ (97% less)	Test in same position as for test 382 of previous series The sand cloud from the vent pipe on the roof of the sand spun pipe plant, was drifting overhead roughly in the direction of the instrument test position

[illegible] Table XLVIII [illegible]
sur[illegible]
the[illegible]
measures detailed above.

TABLE XLVIII SUMMARY OF THERMAL PRECIPITATOR DUST COUNTS IN IRON FOUNDRY W (SAND SPUN PIPE PLANT) AFTER ADOPTION OF FURTHER DUST SUPPRESSION MEASURES, AND COMPARISON WITH SIMILAR COUNTS MADE BEFORE ADOPTION

Sampling Position	Before adoption of further dust suppression measures		After adoption of further dust suppression measures	
	Particles per cc	Median Size	Particles per cc	Median Size
Pneumatic Jolters ('before'), (Converted to pneumatic rammers 'after')				
Top Platform worker	780	0 65μ	295	0 4μ
General atmosphere	610	0 25μ	226	0 45μ
Worker underneath jolters	2 800	0 7μ	277	0 25μ
General atmosphere	1 820	0 8μ	262	0 25μ
Worker underneath jolters	1,230	0 35μ		
General atmosphere	1 140	0 4μ		
Pneumatic Rammers				
Top platform worker	620	0 35μ	385	1 1μ
General atmosphere	475	0 25μ	260	0 85μ
Worker underneath rammers	1 250	0 35μ	253	1 0μ
General atmosphere	980	0 3μ	244	1 1μ
Jolters and Rammers ('before', all rammers 'after')				
In roof at crane men's level	850	0 3μ	385	0 4μ
At shop floor level	520	0 35μ	380	0 65μ
Stripping Plant				
Worker's breathing level	420	0 35μ	200	0 9μ
General atmosphere	350	0 3μ	105	0 8μ
Worker's breathing level	670	0 4μ	83	0 95μ
General atmosphere	850	0 3μ		
No 2 Blow Box worker's breathing level	1,600	0 3μ	120	0 85μ
General atmosphere	410	0 4μ	136	0 7μ
Outside Control Sample				
Outside plant in yard—general atmosphere	165	0 5μ	215	1 1μ

It will be observed that substantial improvements occurred in the working ... of all sections of the foundry tested In the flask filling section ... were effected by the ... pneumatic ... which pre- ... to between ... substituted ... st counts ... as shown ... decrease

Due to the great improvement resulting from ... om jolting to ... the one pneumatic ramming station which ...

comparatively high dust count of 215 particles per cc well outside the plant in the open was due to the considerable amount of dust which failed to be caught in the general exhaust system filtration plant and which was vented through a duct to the outside air above the main factory roof

SUMMARY

Taken in conjunction with medical and X-ray findings on selected workers

dust counts to a range of 83 – 385 partic

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CLINICAL AND X-RAY EXAMINATIONS

BY A I G McLAUGHLIN

At the time that these dust estimations were being made clinical examinations were made of 40 workers and 21 of them had their chests radiographed The plant had only been in operation for 6½ years and most of the workers examined

had between 5 and 6½ years exposure to the conditions in the shop Their occupations were as follows —

Strippers	10
Grinders and Fettlers	8
Coremakers	4
Sandmixers	4
Spinners (casters)	2
Jolters (Top)	2
Jolters (Bottom)	1
Cooling Gantry	2
Crane Driver	1
Fitter	1
Sweeper	1
Drying Stove Attendant	1
Electrician	1
Sand Incinerator	1
All jobs in shop	1
TOTAL	40

The results of the clinical and X-ray examinations are given in Table XLIX

Strippers The job corresponds to the knock-out in an ordinary foundry and [illegible]

therefore that the comparatively short exposure to coal dust in the other 4 cases had not materially contributed to the abnormal X-ray picture As would be expected after such short exposures clinical examination did not reveal evidence of gross disability. In a few cases complaints of dyspnoea were elicited All [illegible]

Grinders and Fettlers Of the 8 grinders and fettlers 3 were X-rayed

CASE 23 A man of 28 years of age, who had worked as a pipe grinder for 5½ [illegible]

CASE 32 Aged 32 years [illegible]

early reticulation

CASE 35 Aged 30 years A fettler and pipe grinder for 6½ years, and previously an iron fettler for 8½ years No symptoms and no abnormal physical signs apart from a somewhat lessened chest expansion (2") The X ray film showed reticulo nodulation consistent with a diagnosis of early silicosis

Of the 5 men who were not X rayed, one (Case 29) had physical signs suggesting the presence of pulmonary tuberculosis He left the factory and his subsequent history is unknown

Coremakers None of the 4 coremakers was X rayed and in none of them were abnormal physical signs found

Sandmixers Three of the 4 sandmixers were X rayed

CASE 9 Aged 27 years Sandmixer for 6 years, previously a blast furnace worker for 1 year Slight cough and sputum but no dyspnoea Breath sounds distant with post tussic crepitations at the bases The X ray film showed reticulo nodulation consistent with a diagnosis of early silicosis

CASE 26 Aged 25 years Sandmixer for 6½ years Slight expectoration but no other symptoms Breath sounds distant, the X ray film showing reticulation ? Early silicosis

CASE 33 Aged 40 years Sand handler for just over 5 years but previously a coal face worker for 13 years Slight expectoration but no cough or dyspnoea *No abnormal physical signs, the X ray film showing reticulation*

Spinners This job corresponds to that of iron casting Only 2 spinners were examined but neither was X rayed One (Case 31) had no symptoms but presented abnormal physical signs and it is likely that X ray evidence of dust inhalation would have been found

Jolters (or Machine Moulders) At first before pneumatic ramming was substituted for jolting this was a very dusty job Two men who worked on the jolter platform were examined

CASE 2 Aged 39 years [illegible] ([illegible] nd but not on coal face) 15 [illegible] Breath sounds distant [illegible] silicosis was made

CASE 18 Aged 24 years Jolter 6 years, previously a moulder in a pipe foundry 3½ years Complained of *some shortness of breath chest expansion* 3½" and no abnormal physical signs found X ray film showed well marked reticulation ? Early silicosis

A THIRD MAN worked in a confined space at the bottom of the jolters his job being to clean the moulds A very dusty job

CASE 5 Aged 29 years Jolter bottom 6½ years Slight cough, chest expansion 1½" No abnormal physical signs a mouth breather X ray film showed well marked reticulation ?Early silicosis

Cooling Gantry Attendants This job consisted of moving the moulds after [illegible] the dust *in the* [illegible] Two men were

CASE 21 Aged 37 years Five years a cooling gantry attendant previously worked at a blast furnace for 5 years Complained of cough and shortness of breath chest expansion 2½" breath sounds distant and post tussic crepitations X ray film showed reticulo nodulation early silicosis

Crane Driver Only one was examined Aged 46 he had worked on this plant for 6½ years, 4½ of which he had spent as a crane driver and 2 as a sweeper Previously he had worked for 21 years in another iron foundry, 4 years as a moulder and 17 as a crane driver He complained of slight cough expectoration and dyspnoea, chest expansion 2¼", a mouth breather, on physical examination he was found to have emphysema with distant breath sounds X ray film showed reticulation, emphysema and early silicosis

Fitter Only one examined Aged 36, a fitter in this plant for 5 years Slight cough and dyspnoea, chest expansion 2" a mouth breather, movement of chest less on left side, with impairment of percussion note and crepitations, X ray film showed increased linear striation but no reticulation or nodulation

Drying Stove Attendant One examined Aged 25 years Drying stoves 6 years Slight cough, expectoration and dyspnoea, chest expansion 3¼" No abnormal physical signs, but X ray film showed reticulation

Electrician The job of the one electrician examined would take him into all parts of the foundry and to intermittent exposure to dust in high concentrations Aged 35 years, had worked on the plant for 6½ years complained of expectoration and slight dyspnoea chest expansion only 1½" mouth breather, X ray film showed early reticulation

Three other men were examined a sweeper a sand incinerator attendant, and a man who had done most of the jobs in the shop None of them was X rayed nor did they have symptoms of abnormal signs in the chest

[illegible] Of the 21 [illegible]

much higher than would be found in an ordinary iron foundry The process of pipe manufacture is highly mechanised and in the early years at least little or no attention was given to dust suppression The results illustrate the danger [illegible]

TABLE XLIX DETAILS OF CLINICAL AND X-RAY EXAMINATIONS AT IRON FOUNDRY W

		Occupations				Clinical Examination								X Ray Examination					
No	Age	Main Occupation	Duration	Other relevant Occupations	Duration	Cough	Sputum	Dyspnoea	Chest Meas	Chest Exc	Abnormal physical signs	Mouth or Nose Breather	I	II	III	IV	Tb	
1	29	Cooling gantry	2½ yrs	Coal screens	1½ yrs	—	Slight	—	34"	3"	B S distant R axilla	Nose		Not X rayed				
2	39	Top of Jolters	6½ yrs	Coal mine	15 yrs	—	—	—	35"	2"	Movt less L side B S distant V R increased	Nose	—	—	—	+	—	Early silicosis
3	30	Core making Spinners	1 yr 1½ yrs	Coal mine	4 yrs	+	+	—	35½"	2"	No abnormal signs	Mouth		Not X-rayed				
4	31	Strippers	5 yrs	Coal mine	Surface 2 yrs Face 4 yrs	+sl	+sl	+sl	33"	2"	No abnormal signs	Nose	—	—	—	—	—	
5	29	Jolters (bottom)	6½ yrs	—	—	+sl	—	—	39½"	1½"	No abnormal signs	Mouth	—	—	+	—	—	
6	46	Casting crane Sweeping	4½ yrs 2 yrs	Iron Foundry Moulder Crane driving	4 yrs 17 yrs	+sl	+sl	+sl	33"	2½"	Emphysematous B S distant	Mouth	—	—	+	—	—	Small opacity R apex
7	36	Fitter	5 yrs	—	—	+sl	—	+sl	33"	2"	Movt less L L P N impd L L L Crepitations	Mouth	+	—	—	—	—	
8	30	Strippers	3 yrs	Coal mine	4 yrs	+sl	+	—	38½"	2"	B S distant	Nose		Not X-rayed				
9	27	Sandmixer	6 yrs	Blast furnace	1 yr	+sl	+	—	36"	3"	B S distant Crepitations at bases	Nose	—	—	—	+	—	Early silicosis
10	26	Coremaking	6 yrs	Sandmixer	5 yrs	—	—	—	35"	1½"	No abnormal signs	Mouth		Not X rayed				
11	17	Sweeping up	1½ yrs	—	—	+	—	—	30½"	2"	No abnormal signs	Mouth		Not X rayed				

TABLE XLIX DETAILS OF CLINICAL AND X RAY EXAMINATIONS AT IRON FOUNDRY W—*continued*

		OCCUPATIONS				CLINICAL EXAMINATION							X RAY EXAMINATION					
									Chest									
No	Age	Main Occupation	Duration	Other relevant Occupations	Duration	Cough	Sputum	Dyspnoea	Meas	Exc	Abnormal physical signs	Mouth or Nose Breather	I	II	III	IV	Tb	
12	26	Stripper	6 yrs	Iron foundry	5 yrs	—	—	+sl	35"	2½"	B S distant	Nose	+	—	—	—	—	
13	18	Coremaker Metal spun	2 yrs	—	—		—	—	35½"	2½"	No abnormal signs	Nose		Not	X rayed			
14	25	Drying stoves	6 yrs	Pipe foundry	2 yrs	—		+sl	39	3½"	No abnormal signs	Nose	—	—	+	—	—	
15	29	Strippers	6½ yrs	Coal mine Pony driver	2½ yrs	—	+sl	—	35½"	3½"	No abnormal signs	Nose	—	—	+	—	—	
16	35	Electrician	6½ yrs	—	—	—	+	+sl	35"	1½"	No abnormal signs	Mouth	—		—	—	—	
17	28	Strippers	6 yrs	Pipe foundry	8 yrs	+sl	+sl	+sl	35"	3"	B S distant A few rhonchi	Nose	—	—	—	+	—	Early silicosis
18	24	Jolters (top)	6 yrs	Pipe foundry	3½ yrs	—	—	+	43"	3½"	No abnormal signs	Nose	—	—	+	—	—	
19	37	Strippers	6 yrs	Blast furnace	3 yrs	+	—		41½"	3½"	B S distant Rhonchi	Mouth	—	—		—	—	
20	32	Labouring Grinding	5 yrs	—	—	—	—	—	33"	2½"	B S distant bases	Nose		Not	X rayed			
21	37	Cooling gantry	5 yrs	Blast furnace	5 yrs	+	—		36	2½"	Movt less R side B S distant base Crepitations R axilla	Nose	—	—	—	+	—	Early silicosis
22	25	Strippers	6 yrs	Coal mine (Haulage)	5 yrs	+	+sl	—	35"	3"	A few high pitched rhonchi	Nose	—	—	—	+	—	Early silicosis
23	28	Pipe grinder	5½ yrs	Coal mine (Surface)	9 yrs	—	—	—	36½"	1½"	B S distant	Mouth	—	—	—	+	—	Early silicosis
24	27	Strippers	6½ yrs	Pipe foundry	2 yrs	+sl	sl	—	38	3"	P N sl impd L upper zone A few clicks	Nose	—	—	—	+	—	Early silicosis
25	23	Strippers	4 yrs	Pipe foundry	4½ yrs	+sl	+sl	—	35½"	2"	No abnormal signs	Nose		Not	X rayed			

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TABLE XLIX DETAILS OF CLINICAL AND X-RAY EXAMINATIONS AT IRON FOUNDRY W—*continued*

OCCUPATIONS					CLINICAL EXAMINATION								X-RAY EXAMINATION					
No	Age	Main Occupation	Duration	Other relevant Occupations	Duration	Cough	Sputum	Dyspnoea	Chest Meas	Chest Exc	Abnormal physical signs	Mouth or Nose Breather	I	II	III	IV	Tb	
26	25	Sandmixer	6½ yrs	—	—	—	+	—	35½"	2"	B S. distant	Nose	—	—	+	—	—	
27	24	Pipe grinder	5½ yrs	Pipe foundry	4½ yrs	+ sl	+sl	—	35"	3"	No abnormal signs	Nose		Not X-rayed				
28	25	Sandmixer Cooling gantry	3 yrs 2 yrs	Iron fettler	4 yrs		—	—	34"	2"	No abnormal signs	Nose		Not X-rayed				
29	28	Pipe grinder	5½ yrs	Iron fettler	8 yrs		+	—	36½"	2"	Rhonchi Crepitations Signs of cavitation	Nose		Not X rayed				?Pulmonary tuberculosis
30	34	Strippers	6 yrs	Coal mine	10 yrs	+sl	+	—	34"	2"	No abnormal signs	Nose		Not X-rayed				
31	21	Spinners	5½ yrs	—	—	—	—	—	33"	3½"	B S distant P t crepitations L axilla and lower lobe	Mouth		Not X-rayed				
32	32	Inside pipe grinder	5½ yrs	—	—	—	—	—	37½"	3"	P N impd crepitations R upper. B S distant Crepitations R upper	Nose	—	+	—	—	—	
33	40	Sand handler	5½ yrs	Coal mine	13 yrs	—	+sl	—	33"	3"	No abnormal signs	Nose	—	—	+	—	—	
34	38	Pipe grinder	3 yrs	Coal mine	15 yrs	—	+sl	—	40"	2½"	No abnormal signs	Nose		Not X-rayed				
35	30	Fettler and pipe grinder	6½ yrs	Iron fettler	8½ yrs	—	—	—	35"	2"	No abnormal signs	Nose	—	—	—	-	—	*Early silicosis*
36	26	Spare man—all jobs	5 yrs.	Coal mine Pipe foundry	3½ yrs 1½ yrs	—	—	—	36"	3"	No abnormal signs	Nose		Not X-rayed				
37	29	Wet grinder	5½ yrs	Iron fettler	6 yrs	—	—	—	35"	3½"	No abnormal signs	Nose		Not X-rayed				
38	30	Core maker	5 yrs.	Iron moulder Crane driver	4 yrs. 9 yrs	—	—	—	36"	2½"	No abnormal signs	Mouth		Not X-rayed				
39	32	Sand incinerator	1 yr	Iron foundry labourer	2½ yrs	—	—	—	36"	2"	No abnormal signs	Nose		Not X rayed				
40	32	Pipe grinder and fettler	4 yrs.	Coal mine	15 yrs.	—	+sl	—	36"	2½"	No abnormal signs	Nose		Not X rayed				

CHAPTER VIII

DUST SAMPLING INVESTIGATIONS IN AN ENGLISH STEEL FOUNDRY

BY KENNETH L GOODALL

With a note on Dust Samples in Steel Foundry M,
BY A I G McLAUGHLIN AND W B LAWRIE

Introduction

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those whose full medical investigation forms the subject of this book Since it was a large, modern and representative foundry however, the dust surveys

DUST COUNTS AND SIZE DISTRIBUTION ESTIMATIONS ON AIR-BORNE DUST SAMPLES FROM STEEL FOUNDRY X

The 42 thermal precipitator and Owen's Jet Dust Counter samples taken in Foundry X related mainly to the processes of shotblasting, roughing-out, small casting fettling and grinding, swing frame grinding, fettling of large castings and wheelabrator work

the size ranges of the atmospheric and other pollution particles and of the

sampling General experience leads one to think that there are probably as many mineral particles due to the process tested present *in the size range under 0 8μ as above, so that it is probable, as far as evaluation is concerned, that the* counts (over 0 8μ basis) now reported represent only about half of the true *values*

... of the overall value of dust counts obtained in steel

time and labour involved in making such evaluations and in obtaining the samples It seems to the author that future dust sampling work in steel foundries *would be more profitably and economically directed, at any rate in the first* instance, towards obtaining instead of dust counts, long period gravimetric

of these measurements are given later in the chapter

In the dust count determinations the thermal precipitator was used to obtain estimates of the average dust concentration over a period of time and to act as a *standard instrument* and the Owen's Jet Dust Counter was used to take snap samples to judge the extent of the dust concentration variation within the period of test occupied by the thermal precipitator measurements, or to ... in cases as in the shot blast chamber tests,

by the thermal precipitator) in the ratio of about

fraction circles

DUST CONCENTRATIONS IN SHOT BLAST CHAMBERS

It was des red to find out how long the dust cloud in a shot blasting chamber took to clear when shot blasting ceased the blast chamber exhaust draught being left on to see what time interval must elapse before it was reasonably safe for a shotblaster to throw open the blasting chamber doors and to take off his helmet The matter was of interest because it was an observed fact that sand and shot blast operators working in chambers often removed their protective helmets inside the chambers and opened the doors immed ately after blasting had ceased The atmosphere inside such chambers was then very heavily laden

concentration in the chamber commences under the influence of the exhaust draught to fall towards the normal atmospheric level but for a certain period

and in Chamber No 2 two large cast ngs one in sand and the other in Compo had been blasted During the tests the vent lating plants were in operation normally and after cessat on of blasting the exhaust was left on and the w cket gate only of each blast ng chamber was opened The results obtained are recorded in Tables L and LI

TABLE L THERMAL PRECIPITATOR AND OWEN S DUST COUNTS IN NO 1 SHOT BLAST CHAMBER IN STEEL FOUNDRY X

Test No and time	Process tested	Dust Concentration particles per cc		Size Distribution		Remarks
		All Particles	Particles over 0 8μ only	All particles	Particles over 0 8μ only	
P 520 2 p m 37 p m	Thermal precip tator sample of general atmosphere inside shot blast chamber No 1 Test started at moment of finishing *the shot blasting of a 6 ft diam* ring cast ng (sandmould) and continued for 15 m ns to cover duration of Owen s snap tests 1(a) 1(f) below	3 780	195	Median Size 0 15μ 35% over 0 2μ (65% less) 10% over 0 5μ (90% less) 3 5% over 1 0μ (96 5% less) 1% over 2 0μ (99% less) % over 5 0μ (100% less)	Median Size 1 25μ 71% over 1 0μ (29% less) 19% over 2 0μ (81% less) 1 5% over 5 0μ (98 5% less)	Samples taken at breathing level During blasting there was considerable intermittent dust escape from gaps near the edges of the ceil ng of this shot blast chamber Only the chamber wicket gate was open during the test the sliding door being closed Little dust escape there
Owen s No 1(a) at 4 ?? p m	Owen s snap sample of general atmosphere inside same shot blast chamber at moment of finishing shot blasting of same casting	3 195	(25	Med an Size 0 3μ 73% over 0 2μ (27% less) 32% over 0 5μ (68% less) 11% over 1 0μ (89% less) 2 5% over 2 0μ (97 5% less) % over 5 0μ (100% less)	Median Size 1 1μ 70% over 1 0μ (30% less) 11 5% over 2 0μ (88 5% less) % over 5 0μ (100% less)	—ditto—
Owen s No 1(b) at 4 24 p m	Ditto 2 minutes after cessation of shot blasting	1 155	127	Median Size 0 25μ 60% over 0 2μ (40% less) 24% over 0 5μ (76% less) 8% over 1 0μ (92% less) 1% over 2 0μ (99% less) % over 5 0μ (100% less)	Median Size 1 0μ 53% over 1 0μ (47% less) 10% over 2 0μ (90% less) –% over 5 0μ (100% less)	—ditto—

TABLE L THERMAL PRECIPITATOR AND OWEN S DUST COUNTS IN NO 1 *SHOT BLAST CHAMBER IN STEEL FOUNDRY X—continued*

Test No and time	Process tested	Dust Concentration particles per cc		Size Distribution		Remarks
		All particles	Particles over 0 8μ only	All particles	Particles over 0 8μ only	
Owen s No *1(c)* at 4 26 p m	Ditto 4 minutes after cessation *of shot blasting*	930	32	Median Size 0 2μ 45% over 0 2μ (55% less) 9% over 0 5μ (91% less) 2% over 1 0μ (98% less) % over 2 0μ (100% less)	Record too sparse for determination of size distribution	—ditto—
Owen s No 1(d) at 4 28 p m	Ditto 6 minutes after cessation of shot blasting	565	8	*Median Size 0 16μ* 37% over 0 2μ (63% less) 7% over 0 5μ (93% less) 1% over 1 0μ (99% less) % over 2 0μ *(100% less)*	—ditto—	—ditto—
Owen s No 1(e) at 4 30 p m	Ditto, 8 minutes after cessation of shot blasting	386	2	Median Size 0 17μ 39% over 0 2μ (61% less) 5% over 0 5μ (95% less) 0 1% over 1 0μ (99 9% less) % over 2 0μ (100% less)	—ditto—	—ditto—
Owen s No 1 (f) at 4 32 p m	Ditto 10 minutes after cessation of shot blasting	210	0	Median Size 0 17μ 42% over 0 2μ (58% less) 5% over 0 5μ (95% less) % over 1 0μ (100% less)	—ditto—	—ditto—

TABLE LI THERMAL PRECIPITATOR AND OWEN'S DUST COUNTS IN NO 2 SHOT BLAST CHAMBER IN STEEL FOUNDRY X

Test No and time	Process tested	Dust Concentra tion particles per cc		Size Distribution		Remarks
		All particles	Particles over 0 8μ only	All particles	Particles over 0 8μ only	
T P 522 5 49 p m 5 58 p m	Thermal precipitator sample of *general* atmosphere inside Shot Blast Chamber No 2 Test started at moment of finishing the shot blasting of 2 large castings one in sand and the other in Compo and continued *for 9* minutes to cover duration of Owen s snap tests 2(a) – 2(e) below	3 630	1 490	Median Size 0 6μ 80% over 0 2μ (20% less) 55% over 0 5μ (45% less) 35% over 1 0μ (65% less) 13% over 2 0μ (87% less) 0 7% over 5 0μ (99 3% less)	Median Size 1 4μ 85% over 1 0μ (15% less) 30% over 2 0μ (70% less) 2% over 5 0μ (98% less)	Sample taken at *breathing level* There was no visible dust escape from the blast chamber wicket gate which was open during the tests the sliding doors being closed During blasting there was *considerable intermittent* dust escape however, from gaps near the edges of the ceiling of this shot blast chamber
Owen s No 2(a) at 5 49 p m	Owen s *snap sample of general* atmosphere inside same shot blast chamber at moment of finishing the shot blasting of same castings	5 500	927	Median Size 0 3μ 65% over 0 2μ (35% less) 34% over 0 5μ (66% less) 13% over 1 0μ (87% less) 2% over 2 0μ (98% less) –% over 5 0μ (100% less)	Median Size 1 15μ 73% over 1 0μ (27% less) 11% over 2 0μ (89% less) –% over 5 0μ (100% less)	—ditto—
Owen s No 2(b) at 5 51 p m	Ditto 2 minutes after cessation of shot blasting.	4 340	1 460	Median Size 0 5μ 80% over 0 2μ (20% less) 48% over 0 5μ (52% less) 23% over 1 0μ (77% less) 6% over 2 0μ (94% less) –% over 5 0μ (100% less)	Median Size 1 25μ 80% over 1 0μ (20% less) 17% over 2 0μ (83% less) –% over 5 0μ (100% less)	—ditto—

TABLE LI THERMAL PRECIPITATOR AND OWEN'S DUST COUNTS IN NO 2 SHOT BLAST CHAMBER IN STEEL FOUNDRY X—*continued*

Test No and time	Process tested	Dust Concentration particles per cc		Size Distribution		Remarks
		All particles	Particles over 0 8μ only	All particles	Particles over 0 8μ only	
Owen's No 2(c) at 5 53 p m	Ditto, 4 minutes after cessation of shot blasting	262	61	Median Size 0 35μ 70% over 0 2μ (30% less) 36% over 0 5μ (64% less) 13% over 1 0μ (87% less) 2% over 2 0μ (98% less) % over 5 0μ (100% less)	Median Size 1 1μ 70% over 1 0μ (30% less) 8% over 2 0μ (92% less) % over 5 0μ (100% less)	—ditto—
Owen's No 2(d) at 5 55 p m	Ditto 6 minutes after cessation of shot blasting	228	40	Median Size 0 3μ 63% over 0 2μ (37% less) 32% over 0 5μ (68% less) 12% over 1 0μ (88% less) 2% over 2 0μ (98% less) % over 5 0μ (100% less)	Median Size 1 1μ 64% over 1 0μ (36% less) 12% over 2 0μ (88% less) % over 5 0μ (100% less)	—ditto—
Owen's No 2(e) at 5 57 p m	Ditto 8 minutes after cessation of shot blasting	72	34	Median Size 0 7μ 84% over 0 2μ (16% less) 62% over 0 5μ (38% less) 36% over 1 0μ (64% less) 3% over 2 0μ (97% less) -% over 5 0μ (100% less)	Record too sparse for determination of size distribution	—ditto—

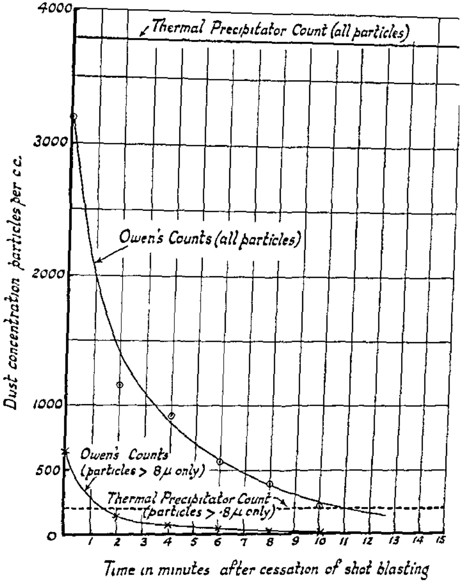


FIG 48 VARIATION WITH TIME AFTER CESSATION OF BLASTING OF DUST CONCENTRATION IN SHOT BLAST CHAMBER NO 1 AT STEEL FOUNDRY X DUST COUNTS MADE FROM THERMAL PRECIPITATOR AND OWEN'S JET DUST SAMPLER RECORDS

From Table L it will be seen that the average dust concentration as measured by the thermal precipitator over the period occupied by the snap Owen's tests was 3,780 particles per cc when every particle visible on the slide (including [illegible]

If only particles over 0 8μ are counted the corresponding average count by Owen's counter (the average of 625, 127, 32 8, 2, and 0 particles per cc) was 132 particles per cc as compared with the 195 particles per cc measured by the thermal precipitator

measured by the thermal precipitator If only particles over 0 8μ are counted, the corresponding average count by Owen's Counter (the average of 927, 1,460, 61 40, and 34 particles per cc) was 504 particles per cc as compared with the 1 490 particles per cc measured by the thermal precipitator

It is clear that the Owen's Counter is not a reliable instrument for estimating absolute dust concentrations since it fails to catch all the dust particles in the volume of air which it samples It is also known to shatter large particles on impingement and so to give erroneous size distributions, but it is useful for giving an idea of the decrease in the dust concentration over a short period

The size distributions for the various samples are listed in Tables L and LI and cannot be further summarised They reflect the large number of tiny pollution particles present and, in the case of particles over 0 8μ only, show median sizes between 1μ and 1 4μ which also represent dust clouds containing a large number of fine particles with practically none over 5μ in size All the [illegible]

The graph in Figure 48 shows the average dust concentration within the chamber after cessation of blasting as measured by the thermal precipitator (a straight line) and the Owen's snap sample values over the same period These latter can be represented very well, within the limits of experimental error by the smooth curves shown, one for all particle counts (including pollution), the other for particles over 0 8μ only Closer agreement than that shown could hardly be expected in the circumstances of the tests which involved working at great speed in semi darkness in a dusty chamber in a very noisy dressing shop, and with a thermal precipitator to attend to, and notes of the conditions and timings to be taken at the same time

In these circumstances an error was made in making the first two Owen's records given in Table LI, the flushing out of the Owen's Counter inlet tube before sampling in the dusty atmosphere of the blast chamber being omitted.

TABLE LII THERMAL PRECIPITATOR AND OWEN'S DUST COUNTS OUTSIDE A SHOT BLAST CHAMBER IN STEEL FOUNDRY X

All counts and size distributions relate to particles over 0.8μ only

Test No and time	Process tested	Dust Concentration	Size Distribution	Remarks
		Particles per cc over 0.8μ	Particles over 0.8μ only	
T.P. 528 2.36 p.m. 2.57 p.m.	Thermal precipitator sample of general atmosphere at breathing level 6 ft outside Shot Blast Chamber in large casting cleaning section of dressing shop	94	Median Size 1.2μ *66% over 1.0μ (34% less)* 24% over 2.0μ (76% less) 2.5% over 5.0μ (97.5% less)	The 2 adjoining shot blast chambers were *both at work on large tank turret castings* moulded in Compo. There were considerable local dust leakages from holes and gaps in the structure of the shot blast chambers. Outside the blast chamber there was no dusty work in progress nearer to the test *position than 20 ft.* Chamber door open for few minutes at end of test but instrument situated 9 ft. from door and to the side of it
Owen's No. 10 2.39 p.m.	Owen's snap sample at same position as above test T.P. 528 and during same period	28	Record too sparse to enable size distribution to be done	—ditto—
Owen's No. 11 2.42 p.m.	Ditto only a large casting had been up-ended 20 ft. away within the previous minute causing a temporary heavy local dust cloud	133	Median Size 1.65μ 85% over 1.0μ (15% less) 35% over 2.0μ (65% less) 2% over 5.0μ (98% less)	—ditto—
Owen's No. 12 2.47 p.m.	Owen's snap sample at same position as above test T.P. 528 and during same period. Sample taken shortly after considerable dust leakage from blast chamber	78	Median Size 1.35μ 72% over 1.0μ (28% less) 31% over 2.0μ (69% less) 1.5% over 5.0μ (98.5% less)	—ditto—
Owen's No. 13 2.57 p.m.	Owen's snap sample at same position as above test T.P. 528 and at end of this test	126	Median Size 1.5μ 81% over 1.0μ (19% less) 29% over 2.0μ (71% less) 0.5% over 5.0μ (99.5% less)	—ditto—

long time in the air owing to their size and to the turbulent conditions within the chamber For part cles over 0 8μ only the dust concentration fell to about 50 particles per cc in 5 minutes or less and if allowance is made for mineral

of the work and so on

DUST CONCENTRATIONS IN THE GENERAL FOUNDRY SHOP

measured by the Owen s apparatus were associated with local dust clouds raised by the up ending of a very large cast ng being fettled some 20 feet away Prior to th s happen ng the concentration was reasonable at 28 particles per cc (O ven s basis) and this desp te various dust leakages noted from holes in the structure of the blast chambers All the size d stributions show that the dust clouds fell almost wholly within the dangerous range under 5μ the median sizes ranging closely around 1 4μ

general atmosphere figure measured by the thermal precipitator in the foun dry nearby at the same time was only 58 particles per cc with median dust cloud size 1 0μ so that the local excess concentrat on at the roughing out posit on

TABLE LIII THERMAL PRECIPITATOR AND OWEN'S COUNTER DUST COUNTS RELATING TO "ROUGHING OUT" IN STEEL FOUNDRY X

All counts and size distributions relate to particles over 0 8μ only

Test No and time	Process tested	Dust Concentration	Size Distribution	Remarks
		Particles per cc over 0 8μ	Particles over 0 8μ only	
T P 523 11 8 a m – 11 41 a.m	Thermal precipitator sample of *general atmosphere of the Dressing* Shop, between 'roughing out' section and section devoted to swing frame grinding and fettling of small castings	58	Median Size 1 0μ 46% over 1 0μ (54% less) 6% over 2 0μ (94% less) 0 5% over 5 0μ (99 5% less)	Test position at breathing level, and not in immediate vicinity of any dusty process *The dust concentration noted was probably* mostly pollution particles
T P 524 11 20 a.m – 11 33 a m	Thermal precipitator sample at *breathing level of men* "roughing-out" very large casting with long pneumatic chisels The test covered the period occupied in taking the Owen's Counter *snap tests* at the same position given below	300	Median Size 2 3μ 87% over 1 0μ (13% less) 57% over 2 0μ (43% less) 11% over 5 0μ (89% less)	Ordinary Compo sand being removed, but the facing sand on this casting was Chamotte A "*Bulk Sample*" (No 1) of the dust falling *from near the chisel* points was collected for chemical analysis for silica and for similar analysis and size distribution determination on its "clay grade" (i e under 10μ) fraction
Owen's No 3 11 22 a m	Owen's snap sample at breathing level of men "roughing out" very large casting with long pneumatic chisels. Taken 2 *minutes after start of* above T P test, at same position	256	Median Size 1 6μ 84% over 1 0μ (16% less) 38% over 2 0μ (62% less) 5% over 5 0μ (95% less)	—*ditto*—
Owen's No 4 11.25 a.m	Ditto, 5 *minutes after* start of T P test	182	Median Size 1 35μ 80% over 1 0μ (20% less) 25% over 2 0μ (75% less) 0 5% over 5 0μ (99 5% less)	—ditto—

TABLE LIII THERMAL PRECIPITATOR AND OWEN'S COUNTER DUST COUNTS RELATING TO 'ROUGHING OUT' IN STEEL FOUNDRY X—*contd*

All counts and size distributions relate to particles over 0 8μ only

Test No and time	Process tested	*Dust* Concentration	Size Distribution	Remarks
		Particles per cc over 0 8μ	*Particles over 0 8μ only*	
Owen's No 5 11 29 a m	Ditto 9 minutes after start of T P test	144	Median Size 1 35μ 76% over 1 0μ (24% less) 29% over 2 0μ (71% less) 2 5% over 5 0μ (97 5% less)	—ditto—
Owen's No 6 11 31 a m	Ditto 11 minutes after start of T P test	125	Median Size 1 35μ 73% over 1 0μ (27% less) 33% over 2 0μ (67% less) 9% over 5 0μ (91% less)	—ditto—

was considerable This local concentration at the roughing-out position was variable and tended to decrease with time, which would be expected as the worst of the dusty moulding sand was removed at the men's first attack The Owen's counts fell from 256 to 182, to 144, to 125 at intervals of a few minutes

Table LIV records various dust measurements made in connection with the

sample) were obtained there at the worker's breathing level in this confined space and though a large number
emery and steel the counts were
clouds were comparatively fine wi
and had median sizes of 1 2μ to
sized)

the workroom and was not taken outside Despite the visible dust leakages

TABLE LIV THERMAL PRECIPITATOR AND OWEN S COUNTER DUST COUNTS RELATING TO FETTLING AND GRINDING PROCESSES IN STEEL FOUNDRY X

All counts and size distributions relate to particles over 0 8μ only

Test No and time	Process tested	Dust Concentration	Size Distribution	Remarks
		Particles per cc over 0 8μ	Particles over 0 8μ only	
T P 525 12 6 p m 12 31 p m	Thermal precipitator sample of general atmosphere in the middle of the small sand-castings grinding and fettling shop	56	Median Size 1 25μ 71% over 1 0μ (29% less) 29% over 2 0μ (71% less) 9% over 5 0μ (91% less)	No dusty work going on within 15 yards of test position, which was at breathing level Work going on in this part of foundry included pneumatic fettling and grinding of small castings at benches (no exhaust) using portable tools and work at 2 swing frame grinders Dust concentration noted was probably mostly pollution particles
T P 526 12 12 p m 12 28 p m	Thermal precipitator sample at breathing level of grinders and fettlers working at bench in small sand-castings grinding and fettling shop	132	Median Size 1 1μ 69% over 1 0μ (31% less) 17% over 2 0μ (83% less) 3% over 5 0μ (97% less)	Test at same time as general atmosphere test 525 above Fettling proper being done by 2 men at each of 4 adjoining benches (of which this was one in the middle) Fettling and grinding by use of portable pneumatic tools was done by the 2 men at each bench, on small castings
Owen s No 7 12 15 p m	Owen s snap sample at breathing level of fettler working on small sand castings with portable pneumatic tool at bench Same bench and time period as in tests T P 525 and T P 526 above	73	Median Size 1 5μ 82% over 1 0μ (18% less) 34% over 2 0μ (66% less) 7% over 5 0μ (93% less)	There was very little moulding sand present on the casting being fettled No exhaust on fettling tool
Owen s No 9 12 22 p m	Ditto with another small sand casting being fettled	14	Record too sparse to enable size distribution to be done	—ditto—

TABLE LIV THERMAL PRECIPITATOR AND OWEN'S COUNTER DUST COUNTS RELATING TO FETTLING AND GRINDING PROCESSES IN STEEL FOUNDRY X—*continued*

Test No and time	Process tested	Dust Concentration	Size Distribution	Remarks
		Particles per cc over 0 8μ	Particles over 0 8μ only	
Owen s No 8 *12 18 p m*	Owen s snap sample at breathing level of grinder working on small sand-castings with small portable grinding wheel at bench Same bench and time period as in tests T P 525 and T P 526 above	260	*Median Size 1 2μ* 70% over 1 0μ (30% less) 21% over 2 0μ (79% less) 2% over 5 0μ (98% less)	Internal grinding was being done No ex haust on grinding wheel A Bulk Sample (No 2) of the dust thrown off by the grinding *wheel* when *internally* grinding this small hollow sand-casting a cylinder 1 3" diam and 1 6" long – was collected for chemical analysis for silica and for similar analysis and size distribution determination on its clay grade (i e under 10μ) fraction
T P 527 3 56 p m 4 23 p m	Thermal precipitator sample at breathing level of 2 *swing frame* grinders in small casting and fettling shop 2 ft diam hollow steel cast ngs being ground No exhaust on grinder	86	Median Size 1 2μ 65% over 1 0μ (35% less) 23% over 2 0μ (77% less) 3% over 5 0μ (97% less)	*Test position was* between 2 grinders (both working nearer to one than the other) Castings being treated had already been sand blasted heat treated and fettled so very little dust left on casting the job here being really *rectification* A *Bulk Sample* (No 4) of the dust thrown off by this swing frame grinding was collected for chemical analysis for silica and for similar analysis and size distribution determination on its clay grade (i e under 10μ) fraction
Owen s No *15* 3 57 p m	Owen s snap sample at breathing level of one of the 2 swing frame grinders referred to in last test T P 527 and in same time period	48	Median Size 1 05μ 56% over 1 0μ (44% less) 16% over 2 0μ (84% less) –% over 5 0μ (100% less)	Except for test position same remarks as above
Owen s No 16 *4 p m*	Ditto on the other of the two swing frame grinders	49	*Median Size 1 2μ* 69% over 1 0μ (31% less) 23% over 2 0μ (77% less) 3% over 5 0μ (97% less)	—ditto—

TABLE LIV THERMAL PRECIPITATOR AND OWEN'S COUNTER DUST COUNTS RELATING TO FETTLING AND GRINDING PROCESSES IN STEEL FOUNDRY X—*continued*

Test No and time	Process tested	Dust Concentration	Size Distribution	Remarks
		Particles per cc over 0.8μ	Particles over 0.8μ only	
Owen's No 14 3 45 p m	Owen's snap sample at breathing level of man fettling small green sand castings with pneumatic chisel on a conveyor belt near floor level	62	*Median Size 1.05μ* 54% over 1.0μ (46% less) 13% over 2.0μ (87% less) –% over 5.0μ (100% less)	A number of workers adjoining the one tested were doing similar work A Bulk Sample (No 3) of the dust thrown off by the fettling chisel was collected for chemical analysis for silica and for similar analysis and size distribution determination on its clay grade (i e under 10μ) fraction
Owen's No 17 4 13 p m	Owen's snap sample at breathing level of man kneeling inside a Compo-moulded tank turret grinding inside of the turret with a small emery grinding wheel	935	Median Size 1.2μ 71% over 1.0μ (29% less) 20% over 2.0μ (80% less) 0.2% over 5.0μ (99.8% less)	A very dense record full of fine mineral and steel particles (rather more mineral than steel particles) Large aggregates present
Owen's No 18 4 19 p m	Repeat of last test	925	Median Size 1.05μ 58% over 1.0μ (42% less) 9% over 2.0μ (91% less) 0.2% over 5.0μ (99.8% less)	—ditto—
Owen's No 19 4 30 p m	Owen's snap sample at breathing level of man kneeling inside large *Compo-moulded tubular casting 8ft* long and 4 ft diam, closed at one end, fettling the inside of the casting with a pneumatic chisel	147	Median Size 1.25μ 75% over 1.0μ (25% less) 27% over 2.0μ (73% less) 1% over 5.0μ (99% less)	Removing the Compo in this confined space was a dusty job

TABLE LV THERMAL PRECIPITATOR AND OWEN'S COUNTER DUST COUNTS RELATING TO WHEELABRATOR PROCESSES IN STEEL FOUNDRY X

All counts and size distributions relate to particles over 0 8μ only

Test No and time	Process tested	Dust Concentration	Size Distribution	Remarks
		Particles per cc over 0 8μ	Particles over 0 8μ only	
Owen s No 20 10 43 a m	Owen s snap sample at breathing level of man placing small green sand castings (car axle boxes) on to conveyor dial feed arrangement to wheelabrator at entry flaps to wheel abrator	98	Median Size 1 25μ 71% over 1 0μ (29% less) 23% over 2 0μ (77% less) 3% over 5 0μ (97% less)	—
Owen s No 21 10 47 a m	Owen s snap sample at breathing level at point near flaps at exit from wheelabrator, where cleaned castings came out on conveyor for removal	51	Median Size 1 4μ 74% over 1 0μ (26% less) 35% over 2 0μ (65% less) –% over 5 0μ (100% less)	—
Owen s No 22 10 51 a m	Owen s snap sample at breathing level at point on conveyor midway between inlet and outlet flaps of wheel abrator where man stood who lowered green sand castings from crane sling on to conveyor dial feed arrangement to wheelabrator	42	Median Size 1 6μ 80% over 1 0μ (20% less) 40% over 2 0μ (60% less) 3% over 5 0μ (97% less)	—
Owen s No 24 11 0 a m	Owen's snap sample of general atmosphere at breathing level outside closed door of wheelabrator blasting chamber while man in sector compartment inside was shot blasting small green sand castings	53	Median Size 1 1μ 58% over 1 0μ (42% less) 12% over 2 0μ (88% less) 1% over 5 0μ (99% less)	—

TABLE LV THERMAL PRECIPITATOR AND OWEN'S COUNTER DUST COUNTS RELATING TO WHEELABRATOR PROCESSES IN STEEL FOUNDRY X—*continued*

Test No and time	Process tested	Dust Concentration	*Size Distribution*	Remarks
		Particles per cc over 0·8μ	Particles over 0·8μ only	
T P 529 10 40 a m 11 2 a m	Thermal precipitator sample of general atmosphere at breathing level adjoining bag filtration plant attached to wheelabrator whilst the latter was working	124	Median Size 1·3μ 72% over 1·0μ (28% less) 23% over 2·0μ (77% less) 2·5% over 5·0μ (97·5% less)	This bag filtration plant vented directly into the atmosphere of the dressing shop at the top of the filter housing Test position was between the filter plant and the office in the dressing shop away from the vicinity of any dusty operation There were visible dust leakages on a considerable scale from the bag filter plant
Owen's No 23 10 55 a m	Owen's snap sample at same position as that of last test T P 529 half way through duration of this last test	74	Median Size 1·3μ 77% over 1·0μ (23% less) 25% over 2·0μ (75% less) % over 5·0μ (100% less)	—ditto—

CHEMICAL AND SIZE ANALYSIS DATA ON VARIOUS DUST SAMPLES FROM STEEL FOUNDRY X

To supplement the information obtainable from the foregoing dust counts and to enable a closer estimate to be made of the potential silicosis risk to be associated with some of the chief dust producing operations it was decided to have chemical analyses and size distribution estimations made on a number of bulk and elutriated samples of dust thrown off by such operations or settled out over long periods from the air in different sections of the foundry For many of the chemical analyses and some of the size gradings of these samples I am greatly indebted to Mr T R Walker MA FRIC and for the remaining chemical analyses to the Government Chemist in whose laboratories they were made

Bulk Sampl s 1 5 Five b lk samples of the dust created by various dusty

the parent dusts and on the eas ly respirable fractions of them The five bulk samples obtained were as follows —

Bulk Sample No 1 "Roughing-out' dust

Dust thrown off a very large casting by the long pneumatic chisels used in the process known as roughing out The casting had been cast in Compo ,

period at points where large volumes of dust were generated The corresponding dust counts made at the same time are given in dust count Table LIII earlier in this chapter

Bulk Sample No 2 Portable grinder dust

nding a small orresponding IV

Bulk Sample No 3 Fettling dust

Bulk Sample No 4 Swing frame grinding dust

Dust thrown on to swing frame grinder s bench from castings being ground Castings being treated had already been sandblasted heat treated and fettled so there was little dust left on the castings The swing frame grinding was more in the nature of rectification The corresponding dust counts made at the same time are given in dust count Table LIV

Bulk Sample No 5 Wheelabrator dust

Dust taken from a casting going through the wheelabrator in the f ttling shop The corresponding dust counts made at the same time are given in dust count Table LV

Mechanical Size Grading of Bulk Samples 1 – 5. Mr T R Walker kindly arranged for this and reported as follows —"The mechanical grading of the samples taken, without separation into metallic and non metallic parts was determined by sieving and elutriation with the results given in Table LVI

TABLE LVI MECHANICAL SIZE GRADING OF BULK SAMPLES 1 – 5

Remaining on B S I Sieve No	Bulk Sample 1 Roughing out dust	Bulk Sample 2 Portable grinder dust	Bulk Sample 3 Fettling dust	Bulk Sample 4 Swing frame grinding dust	Bulk Sample 5 Wheelabrator dust
22	1.3%	1.1%	2.9%	3.6%	0.1%
30	5.1%	3.8%	13.4%	10.2%	0.2%
44	5.3%	3.8%	11.6%	8.1%	5.5%
60	14.1%	6.8%	20.1%	14.1%	15.4%
72	16.8%	5.7%	11.4%	7.6%	10.2%
100	24.9%	7.1%	11.4%	10.3%	13.4%
150	15.9%	7.3%	10.6%	13.4%	20.7%
Pass 150	2.3%	8.4%	2.3%	20.7%	11.7%
Silt Grade	9.3%	5.7%	13.1%	10.4%	21.9%
Clay Grade	5.0%	0.5%	3.2%	1.6%	0.9%

In the mechanical grading the silt grade and the clay grade were removed by currents of water of a velocity adequate to take away —

(a) for the silt grade, particles between 10μ and 100μ in diameter

(b) for the clay grade, particles up to 10μ in diameter

The velocities assume that the specific gravity of the particles is that of silica or clay, which are close together The velocities are insufficient to remove steel particles of diameters larger than these so that the figures quoted for silt and clay grades are higher than they ought to be

Mr T R Walker's Chemical Analyses of Bulk Samples 1 – 5 Mr Walker reported – "The samples were separated by a magnet into metallic and non metallic portions with the results given in Table LVII Table LVIII gives the analyses of the non-metallic portions

TABLE LVII PERCENTAGES OF METALLIC AND NON-METALLIC DUSTS IN BULK SAMPLES 1 – 5

	Bulk Sample 1 Roughing out dust	Bulk Sample 2 Portable grinder dust	Bulk Sample 3 Fettling dust	Bulk Sample 4 Swing frame grinding dust	Bulk Sample 5 Wheelabrator dust
Metallic	0%	76.3%	1.5%	85.8%	46.7%
Non metallic	100%	23.7%	98.5%	14.2%	53.3%

TABLE LVIII CHEMICAL ANALYSES OF THE NON-METALLIC PORTIONS OF BULK SAMPLES 1 – 5

	Bulk Sample 1 Roughing out dust	Bulk Sample 2 Portable grinder dust	Bulk Sample 3 Fettling dust	Bulk Sample 4 Swing frame grinder dust	Bulk Sample 5 *Wheelabrator* dust
SiO_2(Total)	85 12%	20 56%	94 08%	14 06%	93 48%
Fe_2O_3	2 00%	0 95%	3 29%	5 98 %	2 57%
Al_2O_3	9 40%	74 10%	1 31%	74 28%	2.03%
CaO	0 76%	0 10%	0 36%	0 20%	0 32%
MgO	0 40%	0 18%	0 25%	Trace	0 25%
Loss on ignition	1 20%	5 84%	Nil%	6 96%	Nil%

Considering the chemical analysis it is evident that —

Bulk Sample No 1 consisted of mould material entirely,

Bulk Sample No 2 was a mixture of ground metal and ground off grinding wheel

Bulk Sample No 3 looked like a mixture of moulding sand and core sand,

Bulk Sample No 4 was again a mixture of ground off metal and grinding wheel with apparently a proportion of scale, while

Bulk Sample No 5 was a mixture of metal and mould or core material, some of the metal consisting of broken down shot '

Mr Walker concluded that 'The results cannot be regarded as completely [illegible]

and 'hard free silica [illegible] follows —

[illegible] 100 mesh B S S sieve Small portions [illegible] Samples 2, 4, and 5 could not be [illegible] ained are given in Table LIX

All the samples contain metallic iron, the amount in Bulk Samples Nos 2 and [illegible] too large Since these samples are different from a simple mixture of

TABLE LIX GOVERNMENT LABORATORY ANALYSES OF BULK SAMPLES 1 – 5 FOR TOTAL, AMORPHOUS, AND HARD FREE SILICA

	Bulk Sample 1 Roughing out dust	Bulk Sample 2 Portable grinder dust	Bulk Sample 3 Fettling dust	Bulk Sample 4 Swing frame grinder dust	Bulk Sample 5 Wheelabrator dust
Total Silica as SiO_2	84 8%	7 2%	91 5%	2 8%	74 2%
Hard free silica un corrected for residue	74 4%	4 9%	84 8%	1 9%	73 3%
Residue after fluoboric acid and HF acid treatment	0 8%	19 0%	1 7%	10 4 %	2 2%
Silica ex tracted by 5% Sodium Carbonate solution (i e amorphous silica)	Negligible	Negligible	Negligible	Negligible	Negligible

TABLE LX GOVERNMENT LABORATORY ESTIMATES OF FREE SILICA CONTENTS OF BULK SAMPLES 1 5

	Bulk Sample 1 Roughing out dust	Bulk Sample 2 Portable grinder dust	Bulk Sample 3 Fettling dust	Bulk Sample 4 Swing frame grinder dust	Bulk Sample 5 Wheelabrator dust
Hard free silica present in amounts not less than	70%		80%		70%
Hard free silica present in amounts probably not exceeding		5%		2%	

Comparison between Mr Walker s Silica Analyses on Bulk Samples 1 – 5 and

ance is made for these differences the two sets of figures for total silica content agree *reasonably well* The Government Laboratory sodium carbonate extraction test indicates the absence from the samples of any amorphous silica The Government Laboratory took the analyses further than Mr. Walker by giving (Table LX) estimates of the hard free silica present in each sample. If these figures related tc
to the extent of the sili
obtained relate, as the
to the size range of d
lung tissue, but to dust samples ranging from the finest fraction below 10μ (the clay grade) right up to coarse material sufficiently large to remain on a 22 B S.I. sieve

It was, therefore, only possible to agree with Mr. Walker when he said, in concluding his report, that the results were of very limited value as "by far the

Since the size range of interest from the silicosis risk viewpoint is that under

TABLE LXI SIZE FREQUENCY DISTRIBUTION DETERMINATIONS MADE UNDER THE HIGH POWER MICROSCOPE ON CLAY GRADE SAMPLES 1–5

	Clay Grade Sample 1 Roughing out dust	Clay Grade Sample 2 Portable grinder dust	Clay Grade Sample 3 Fettling dust	Clay Grade Sample 4 Swing frame grinder dust	Clay Grade Sample 5 Wheelabrator dust
Size distribution including all particles visible on slide after incineration	Median Size 0.45μ 76% over 0.2μ (24% less) 48% over 0.5μ (52% less) 27% over 1.0μ (73% less) 7.5% over 2.0μ (92.5% less) % over 5.0μ (100% less)	Median Size 0.65μ 77% over 0.2μ (23% less) 56% over 0.5μ (44% less) 35% over 1.0μ (65% less) 12% over 2.0μ (88% less) % over 5.0μ (100% less)	Median Size 0.45μ 77% over 0.2μ (23% less) 47% over 0.5μ (53% less) 24% over 1.0μ (76% less) 7% over 2.0μ (93% less) 0.3% over 5.0μ (99.7% less)	Median Size 0.3μ 64% over 0.2μ (36% less) 33% over 0.5μ (67% less) 16% over 1.0μ (84% less) 4.5% over 2.0μ (95.5% less) % over 5.0μ (100% less)	Median Size 0.25μ 56% over 0.2μ (44% less) 30% over 0.5μ (70% less) 17% over 1.0μ (83% less) 7% over 2.0μ (93% less) 0.2% over 5.0μ (99.8% less)
Size distribution for particles greater than 0.8μ only after incineration	Median Size 1.25μ 79% over 1.0μ (21% less) 36% over 1.5μ (64% less) 18% over 2.0μ (82% less) 5% over 3.0μ (95% less) % over 5.0μ (100% less)	Median Size 1.5μ 85% over 1.0μ (15% less) 50% over 1.5μ (50% less) 29% over 2.0μ (71% less) 6% over 3.0μ (94% less) % over 5.0μ (100% less)	Median Size 1.25μ 77% over 1.0μ (23% less) 36% over 1.5μ (64% less) 21% over 2.0μ (79% less) 8% over 3.0μ (92% less) 0.7% over 5.0μ (99.3% less)	Median Size 1.3μ 73% over 1.0μ (27% less) 40% over 1.5μ (60% less) 21% over 2.0μ (79% less) 5% over 3.0μ (95% less) % over 5.0μ (100% less)	Median Size 1.35μ 80% over 1.0μ (20% less) 44% over 1.5μ (56% less) 31% over 2.0μ (69% less) 17% over 3.0μ (83% less) 3% over 5.0μ (97% less)
Largest individual particles noted anywhere on the dispersed dust slide	8μ	6μ	10μ (and one of 15μ)	7μ	10μ and 12μ

The first ob

dispersed

Table LXI attest, that there
10μ in size and most of the
between 5μ and 10μ The second observation is that if the size distribution figures for particles over 0 8μ only are compared with the corresponding figures for air borne dust samples taken in the fo

results of this kind

From this, or even from a consideration of the clay grade size distribution results for particles over 0 8μ only as they stand, it follows that the clay grade samples represent dust, all of which if dispersed as dust clouds, would be capable of entering the ultimate tissues of the lungs These clay grade samples were thus suitable for silica analyses to assess the silicosis risk which would arise if dust clouds derived from them were inhaled and were therefore sub mitted to the Government Laboratory for estimation of their silica content

Government Laboratory Analyses of Clay Grade Samples 1 – 5 The Government Laboratory analysed the clay grade samples for total silica and hard free silica with the results set out in Table LXII, and concluded that the free silica determinations, made by the long fluoboric acid method, should be regarded as approximate only

TABLE LXII

GOVERNMENT LABORATORY SILICA ANALYSES OF CLAY GRADE SAMPLES 1 – 5

	Clay Grade Sample 1 Roughing out dust	Clay Grade Sample 2 Portable Grinder dust	Clay Grade Sample 3 Fettling dust	Clay Grade Sample 4 Swing frame grinder dust	Clay Grade Sample 5 Wheelabrator dust
Total silica as SiO_2	49 1%	—*	78 2%	—*	—*
Hard free silica uncorrected for residue	9%	5%	49%	4%	25%
Residue after fluoboric and HF acid treatment		2 4%			

* Owing to the small amounts of clay grade samples 2 4 and 5 the total silica determinations were not made

A comparison of these hard free silica percentages with the corresponding percentages in the bulk samples (Table LIX) is instructive as emphasizing the danger of drawing conclusions as to the silicosis risk from analyses of the parent dust as opposed to those of the respirable fraction under 10μ (the clay grade) It will be seen that Bulk Sample 1 gave a hard free silica analysis of 74 4% while only 9% was present in the clay grade fraction of the same sample The roughing out dust risk is thus very much less from the silicosis viewpoint than appeared at first sight

whose presence in the lung tissues is probably only less undesirable than that of quartz itself

portable grinder operations and swing frame grinding all contain less than

weighed the clouds to be

Swing frame grinding work (very low risk)

It is stressed that this classification is only very approximate as it is based on a limited number of dust counts and does not take fully into account the amount of time continuously spent by the respective workers in the dust concentration conditions measured As a first approximation however, it is instructive, even if it only emphasizes the comparatively small silicosis risk run by swing frame grinders

EXAMINATION OF LONG PERIOD SAMPLES OF AIR SETTLED DUST IN STEEL FOUNDRY X

As another method of throwing some light on the silicosis hazard in steel foundries and with a view to supplementing further the information already given it was decided to obtain and analyse samples of dust which would represent what was being actually deposited on surfaces in the foundry by settlement from the air of the foundry

of a clay grade fraction were obtained These various samples were treated in a generally similar manner to Bulk Samples 1 – 5 as already described

The samples of air settled dust obtained were as follows —

Lo ... n air

Lo ... sub

Lo ... the

Long Period Sample R1 Same as Sample R only for a later period of 10 days subsequent to the removal of Sample R The *sample weighed 8 36 grams*

It will be seen that Samples P and P1 should be essentially similar as also Samples R and R1

... of Long

and LXV

TABLE LXIII MECHANICAL SIZE GRADING OF LONG PERIOD SAMPLES P P1 Q R & R1

Remaining on B S I Sieve No	Long Period Sample P Dust on fettling shop air ventilation duct	Long Period Sample P1 Same as dust P only later sample	Long Period Sample Q Dust from roof of shot blast chamber	Long Period Sample R Dust from top of wheel abrator dust chamber	Long Period Sample R1 Same as dust R only later sample
8	0 43%	Nil	Nil	1 96%	Nil
10	0 22%	Nil	Nil	8 46%	Nil
16	0 41%	0 925%	Nil	1 20%	0 200%
22	1 24%	1 175%	Nil	1 13%	0 086%
30	1 40%	1 500 %	0 14%	0 94%	0 371%
44	1 27%	0 825%	0 98%	0 20%	0 157%
60	2 38%	1 650%	1 16%	0 24%	0 157%
72	1 92%	0 675%	0 98%	0 20%	0 143%
85	0 91%	0 275%	0 63%	0 08%	0 057%
100	0 96%	0 175%	0 98%	0 13%	0 057%
150	2 98%	0 475%	3 87%	0 56%	0 543%
Pass 150	9 05%	2 925%	20 80%	39 10%	42.200%
Silt Grade	56 59%	66 550%	53 46%	39 50%	47 672%
Clay Grade	20 24%	22 850%	17 00%	6 30%	8 357%

TABLE LXIV PERCENTAGES OF METALLIC AND NON METALLIC DUSTS IN LONG PERIOD SAMPLES P, P1, Q, R AND R1

	Long Period Sample P Dust on fettling shop air ventilation duct	Long Period Sample P1 Same as dust P only later sample	Long Period Sample Q Dust from roof of shot blast chamber	Long Period Sample R Dust from top of wheelabrator dust chamber	Long Period Sample R1 Same as dust R only later sample
Metallic	15.64%	48.48%	66.66%	92.97%	93.59%
Non Metallic	84.36%	51.52%	33.34%	7.03%	6.41%

TABLE LXV CHEMICAL ANALYSES OF THE NON METALLIC PORTIONS OF LONG PERIOD SAMPLES P, P1, Q, R AND R1

	Long Period Sample P Dust on fettling shop air ventilation duct	Long Period Sample P1 Same as dust P only later sample	Long Period Sample Q Dust from roof of shot blast *chamber*	Long Period Sample R Dust from top of wheelabrator dust *chamber*	Long Period Sample R1 Same as dust R only later *sample*
SiO_2 (Total)	29.12%	31.10%	56.60%	33.52%	37.86%
Fe_2O_3	34.60%	38.32%	11.00%	26.31%	27.91%
Al_2O_3	6.14%	6.18%	12.58%	19.97%	21.59%
CaO	3.25%	1.85%	2.00%	2.58%	1.34%
MgO	1.95%	1.88%	2.02%	2.53%	2.42%
Loss on ignition	20.16%	16.28%	12.98%	11.84%	9.77 %

TABLE LXVI GOVERNMENT LABORATORY ANALYSES OF LONG PERIOD SAMPLES P, P1, Q, R AND R1 FOR TOTAL AND FREE SILICA

	Long Period Sample P *Dust on fett*ling shop air ventilation duct	Long Period Sample P1 *Same as* dust P only later sample	Long Period Sample Q *Dust from* roof of shot blast chamber	Long Period Sample R *Dust from* top of wheelabrator dust chamber	Long Period Sample R1 *Same as* dust R only later sample
Total silica as SiO_2	26.0%	28.8%	47.4%	10.7%	14.0%
Hard free silica	16%	20%	2		

As in the case of the earlier work on the Clay Grade Samples 1 – 5, the elutriations made by Mr Walker are seen from Table LXVII to have been equally effective in giving substantially a clean cut of the materials at 10μ. Direct microscopical examination of these dispersed samples shows (Table LXVII) that there is next to nothing in any of the samples over 10μ in size and that most of the material is well below 10μ, there being little between 5μ and 10μ. The size frequency distribution figures are in fact typical of industrial air-borne dust clouds and it can be stated with certainty that these clay grade samples represent dust, substantially all of which if dispersed as dust clouds, *would be capable of entering the ultimate tissues of the lungs*

These Clay Grade Samples were thus suitable for silica analyses to assess the silicosis risk which would arise if dust clouds derived from them were inhaled and the samples were therefore submitted to the Government Laboratory for estimation of their silica content

Government Laboratory Analyses of Clay Grade Samples P, P1, Q, R and R1
The Government Laboratory analysed the Clay Grade Samples for hard free silica and reported the results shown in Table LXVIII

TABLE LXVIII GOVERNMENT LABORATORY FREE SILICA ANALYSES OF CLAY GRADE SAMPLES P, P1, Q R AND R1

Material unattacked by fluoboric acid	Clay Grade Sample P Dust on fettling shop air ventilation duct	Clay Grade Sample P1 Same as dust P only later sample	Clay Grade Sample Q Dust from roof of shot blast chamber	Clay Grade Sample R Dust from top of wheel abrator dust chamber	Clay Grade Sample R1 Same as sample R only later sample
A Loss with HF acid (as % of sample)	15 5%	15 1%	12 2%	7 7%	11 5%
B Residue (as % of sample)	2 3%	3 4%	1 5%	4 3%	6 0%

The Government Chemist s report on the results shown in Table LXVIII stated that the figures in Column A, i e the loss on treatment with hydrofluoric [illegible]

cluded that —
Clay Grade Samples P, P1 and Q may contain small proportions of hard free silica in amounts not more than 15%, 15% and 12% respectively, and that *Clay Grade Samples R and R1* are practically free from hard free silica" (which means presumably that the amounts are not more than 7% and 11% respectively)

as each other because (a) Samples P and P1 were taken at the same place

tions going on therein and mixed up by general air movement

rough estimates as to the order of risk of the various processes The results obtained however are of general interest as showing that for Clay Grade Samples of foundry dusts obtained either from bulk samples of the parent dusts or from dusts settled from the foundry air the hard free silica percentages with few exceptions are reasonably low It is to be hoped and indeed expected from work now in progress by other workers in steel foundries that when

obtained direct from the foundry air by the salicylic acid filtration apparatus were analysed by X ray diffraction for free silica The results showed that

SUMMARY

With a view to forming some tentat ve estimates of the sil cosis hazards in steel foundries dust count and size distribution determinations were made

of blasting and so to determine the time interval which should elapse before it would be safe for a shotblaster to discard his helmet and throw open the blast chamber doors An interval of about 5 minutes was suggested by the results obtained

Reference is made as in the previous chapter on dust sampling in an iron foundry to the grave difficulties associated with the evaluation of dust count samples obtained in steel foundries and the conclusion is again drawn that future workers making dust sampling investigations in this field would be more profitably employed in obtaining instead of dust counts long period gravimetric samples of the air borne dust less than 5μ for mass concentration estimations supplementing this information by X ray diffraction and chemical (especially silica) analyses on the samples so obtained and by stain method measurements of the general nuisance dirtiness of steel foundry atmospheres as opposed to their silicosis producing potentialities In the present investigation it was only possible to do a limited amount of work in this direction and to supplement the dust count and size distribution data and with the collaboration of Mr T R Walker M A F R I C and the Government Laboratory, various size grading and size distribution estimations and chemical and total and free silica analyses on a number of bulk samples of dust thrown off by various dusty typical foundry operations or settled from the foundry air were made and also similar analyses on elutriated fractions under 10μ derived from these samples

The results emphasize the dangers inherent in attempts to assess silicosis hazards from analyses of the parent dusts instead of on the respirable size

the under 10μ fractions of dust thrown off by the processes of swing frame grinding portable grinder work roughing out wheelabrator work and pneumatic chisel fettling

For similar under 10μ fractions of dust settled from the foundry air near wheelabrators shot blast chambers and fettling shops the free silica percentages varied between 7 and 15%

Weighting the free silica percentage results with the dust count survey results, the silicosis hazard appeared to be greatest for fettling work with pneumatic chisels and least for swing frame grinding with roughing out wheelabrator work and portable grinder work falling in between

DUST ESTIMATIONS AT STEEL FOUNDRY M

BY A I G McLAUGHLIN AND W B LAWRIE

During the time that the clinical and radiographic examinations were being made at Foundry M a series of dust samples was taken with the Owen s Dust Counter to show the difference between the conditions in the moulding and fettling shops

The factory buildings (see Fig 49) consist of (1) a large foundry where sand moulding melting and casting of steel is done (2) a small moulding shop, (3) a fettling or steel dressing shop (4) a pattern or woodworking shop where wooden patterns for the sand moulds are made (5) a machine shop and (6) ... offices canteen etc ... to the eaves

of the gabled roof

in the roof A converter furnace is situated at one end of the ... Siemens open hearth furnace near the middle The sand moulders work at

various parts of the foundry floor A sand mill for the preparation of the

powder is applied to the moulds, little or no dust being evolved during its application Silica paint was used before the war on only 5% of the moulds Those made with Belgian sand did not need to be painted During the war Belgian sand was unobtainable and the moulds made with English sand had to be painted, and a ½ ton of silica flour had been used during the war period

The sand moulders use a jet of compressed air to blow loose dust off the surface of the moulds and in so doing blow dust into the atmosphere of the

from the molten steel Steel castings of many shapes and sizes are made, the heaviest being 3 tons 5 cwts and the lightest 2 oz The average size of casting made is ¾ cwt The atmosphere of the foundry is much less dusty than that of the fettling shop

Fettling Shop The fettling shop which is well away from the moulding shop measures 300 feet by 50 feet It is 22 feet high to the eaves and 32 feet to the louvred ventilator running along the roof At one side of the shop is a lean to about 15 feet high Double doors are situated at each end of the shop and another in the middle of the long south wall Two rows of windows of which only the lower ones open are situated along the north wall Another

oxide from the welding booths

the samples were taken are marked on the plan In each shop samples were taken in one of the crane cabins about 14 feet above floor level

The samples were photographed under standard conditions on a Vickers microscope at a magnification of 1 000 Small portions of the microscopic fields are reproduced (see Fig 49) It will be seen that all samples taken in the fettling shop (1 – 16) show heavy dust concentrations whereas those in the

welding booth and the dust particles have different physical characteristics from the remainder of the samples taken in the fettling shop It is probable

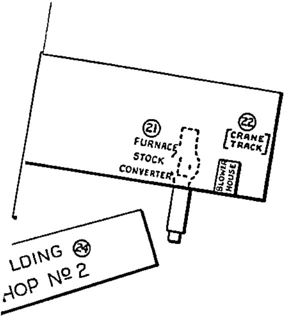
count and size distribution was as follows —

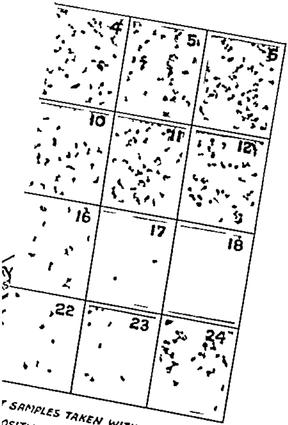
The 24 samples were also estimated by a method devised by one of us (W B L)(109) which is now being used by the British Iron and Steel Research Association(110) The following Table LXIX gives the dust counts shown by these samples —

TABLE LXIX DUST COUNTS AT FOUNDRY M

No	*Particles/cc*	*Remarks*
1	6 400	Fettling Shop General atmosphere near cleaning process
2	12,800	
3	12 800	
4	12 800	Breathing level at rough fettling
5	12 800	Between 2 fettlers 8 feet apart
6	12 800	Grinders Between 2 abrasive wheels
7	12 800	Fettling Shop Fettling clean casting
8	12 800	Breathing level Casting previously shotblasted
9	12 800	
10	12 800	
11	12 800	
12	12 800	
13	3 200	
14	12 800	
15	9 600	
16	12 800	
17	800	Moulding Shop
18	800	
19	800	
20	1 200	
21	12 800	Near converters
22	12 800	Crane track level
23	12 800	Near open hearth furnace
24	2 400	Small Moulding Shop General atmosphere

These figure ... ntra on of 12 800 part cles per cubic centimetre in ... in the moulding sho ... verter the dust clou ... metre though these clouds probably consist largely of iron oxide





SAMPLES TAKEN WITH THE OWENS
OSITIONS MARKED ON PLAN — 1000 x

ELTTL NC SHOPS

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The 24 sample
(W B L)[109], whıc
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No	Partıcles/cc
1	6 400
2	12 800
3	12 800
4	12 800
5	12 800
6	12 800
7	12 800
8	12 800
9	12 800
10	12 800
11	12 800
12	12,800
13	3 200
14	12 800
15	9 600
16	12 800
17	800
18	800
19	800
20	1 200
21	12 800
22	12 800
23	12 800
24	2 400

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Table LXX shows the results of X-ray examinations of the workers in the

having silicosis

TABLE LXX FACTORY M RESULTS OF X RAY EXAMINATIONS MOULDING SHOP

Occupation	Total	Under 2 yrs	2 5 yrs	6-10 yrs	11 15 yrs	16-20 yrs	21 25 yrs	26-30 yrs	Over 30 yrs
				Length of Employment					
Moulders	89	6	10	‖ 18	6	**‖ 10	*** ††† 12	*** ††† 10	***††† ††††‖ 17
Foundry Manager	1		—	1	—	—	—	—	—
Furnace hands	4	—	1	†1	1	—	—	†1	—
Furnace bricklayers	2	1	1	—	—	—	—	—	—
Bricklayers labourer	1	—	—	—	—	—	†1	—	—
Casters	2	—	—	1	—	1	—	—	—
Slingers	3	—	1	—	—	—	—	†1	*1
Coremaker	1	—	—	—	—	1	—	—	—
Moulding Machine hands	2	—	1	†1	—	—	—	—	—
Sand mixers (mill)	2	—	*1	*1	—	—	—	—	—
Ladleman	1	—	—	—	*1	—	—	—	—
Labourers	2	1	—	*1	—	—	—	—	—
Crane drivers	4	—	—	1	1	*1	*1	—	—
TOTALS	114	8	15	25	9	13	14	12	18

SUMMARY

* Early reticulation	18 cases
† Reticulation	18 cases
‖ Tuberculosis	3 cases
‡ Nodulation	Nil
Normal	75 cases
Total	114 cases

TABLE LXXI. FACTORY M RESULTS OF X-RAY EXAMINATIONS
FETTLING SHOP

Occupation	Total	Length of Employment Under 2 yrs	2 5 yrs	6-10 yrs	11 15 yrs	16-20 yrs	21-25 yrs	26-30 yrs	Over 30 yrs
Steel dressers (fettlers)	66	2	** 20	***** ††††† ††††‖ 21	** ††††† †§‖ 11	† ‡‡‡ 4	*† ‡‡§ 5	—	‡‡§ 3
Sandblasters	4	—	*†3	—	—	§1	—	—	—
Grinders	1	—	—	*1	—	—	—	—	—
Welders	4	—	—	†1	†1	†1	—	‡1	—
Oxyacetylene burners	5	—	†2	††3	—	—	—	—	—
Fettlers labourers	2	1	†1	—	—	—	—	—	—
Crane drivers	3	—	—	†2	—	†1	—	—	—
Fitters and turners	5	—	—	1	*4	—	—	—	—
Wheelabrator operators	2	—	1	1	—	—	—	—	—
Castings cleaner	1	1	—	—	—	—	—	—	—
Totals	93	4	27	30	16	7	5	1	3

SUMMARY

* Early reticulation	13 cases
† Reticulation	27 cases
‡ Nodulation	8 cases
§ Massive shadows	4 cases
‖ Tuberculosis	2 cases
Normal	39 cases
Total	93 cases

CHAPTER IX

HEALTH RISKS OF THE VARIOUS FOUNDRY OCCUPATIONS

BY A I G McLAUGHLIN

We propose in this chapter to examine the information which has been obtained from all sources about the risk of lung diseases to foundry workers in general and also the relative risks of the various occupations in the industry The published work on foundry health risks is discussed in the first chapter but it will be convenient to refer again to some of the investigations in connection with specific occupations

FOUNDRY WORKERS IN GENERAL

INCIDENCE OF THE PNEUMOCONIOSES AND TUBERCULOSIS

Intensive studies of the health of foundry workers began only in 1931 and since then about 25 radiographic and/or clinical surveys of various groups have been made It is difficult to make satisfactory comparisons between the results

of first stage silicosis ranges from 0 99 to 40 per cent of second and third stage silicosis from 0 1 to 64 per cent The incidence of silicosis combined with tuberculosis varies from 0 25 to 12 per cent whereas that of active tuberculosis is between 0 6 and 32 per cent The high percentages almost inevitably occur when only small numbers or when specialized groups exposed to high dust concentrations have been examined The studies however have been carried out in at least nine different countries and there is unanimity about the occurrence of silicosis and pneumoconiosis in iron steel and non ferrous foundry workers

* These figures refer to the results of the field investigation described in Chapter IV and do not include the cases recorded in the files of the Factory Department and the Silicosis Medical Board Chap VI nor those described in the pathological studies Chap V

work in the least dusty or dangerous foundry occupations There is little doubt that individual foundry occupations vary not only in dustiness but that the

pneumoconiosis Most observers who have been able to compare the incidence of the pneumoconioses in iron and steel foundries (McConnell and Fehnel

Greenburg Siegal and Ross Smith (1938))

ies produces more cases than comparable

of them however e g McConnell and Fehnel found that the incidence of silicosis was only slightly higher in steel than in iron foundries On the other hand our figures (see Table II) show that steel workers have a much higher incidence of severe X ray abnormalities than do iron or mixed iron and steel workers For instance 16 per cent of the steel

lung which is not made up of whorled silicotic nodules but

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radiographic changes were also found in all occupations in steel moulding shops and less often in iron and mixed iron and steel moulding shops though again small numbers are involved Marked radiographic changes occurred seldom in pattern and coreshop workers maintenance and administrative staff in all types of foundries

It is clearly shown that any worker in a steel fettling shop is exposed to the

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SPECIFIC OCCUPATIONS

SAND AND SHOTBLASTERS

In the general investigation,
iron, 22 from steel and 11 from
5 had normal chests and the ot

sand

Between 1931 and 1947 inclusive, 79 deaths (23 from silicosis, 43 from silicosis and tuberculosis and 13 from other causes) came to the notice of the Silicosis Medical Board Over the same period there were 41 certificates of

work in the least dusty or dangerous foundry occupations There is little doubt that individual foundry occupations vary not only in dustiness but that the

(1934) Sander (1938) (1939) and Greenburg Siegal and Ross Smith (1938)) agree that exposure in steel foundries produces more cases than comparable exposure in iron foundries Some of them however e g McConnell and Fehnel found that the incidence of silicosis was only slightly higher in steel than in iron foundries On the other hand our figures (see Table II) show that steel workers have a much higher incidence of severe X ray abnormalities than do iron or mixed iron and steel workers For instance 16 per cent of the steel

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shops and less often in iron and mixed iron and steel moulding shops though again small numbers are involved Marked radiographic changes occurred seldom in pattern and coreshop workers *maintenance and administrative* staff in all types of foundries

It is clearly shown that any worker in a steel fettling shop is exposed to the risk of contracting severe X ray abnormalities which may in most cases be

It is not clear why pattern shop workers in steel foundries should have a higher incidence of severe X-ray changes than pattern shop workers in steel or iron foundries The pattern shops in most foundries are separate from the moulding, fettling and core shops and the main exposure in each pattern shop is to wood dust

SPECIFIC OCCUPATIONS

SAND AND SHOTBLASTERS

In the general investigation, 43 sand or shotblasters were X rayed, 10 from iron, 22 from steel and 11 from mixed foundries (Table VI) In the iron group 5 had normal chests and the other 5 had early X-ray reticulation There were

malities the ratio for sand and shotblasters in iron foundries was 0 ± 83, in steel foundries 319 ± 68, and for mixed foundries 117 ± 108 It is fairly clear that the ratio for blasters of iron castings does not represent the actual risk

sand

Between 1931 and 1947 inclusive, 79 deaths (23 from silicosis, 43 from sili-

varied from 3 56 per cent to 7 87 per cent, total silica from 0 87 to 2 60, free silica from 0 17 to 0 75 and Fe_2O_3 from 0 16 to 1 43 per cent (all percentages of dry weight of the lungs)

One case (No 38 of the pathology series) a shotblaster for 20½ years died at 48 years of age and histologically only slight silicosis was found This is the only blaster giving a history of having always used shot and not sand as an abrasive Apart from this case we have no evidence as to whether the dust

Grinding of Metals (Miscellaneous Industries) Regulations 1925 have played a part in the small amount of silicosis in the case cited above and also in maintaining the number of cases of silicosis and tuberculosis at a fairly low figure since 1925 Few dust control methods are completely efficient and even with stringent regulations cases of lung disease in sand or shotblasters still occur There is no doubt that sand or shot blasting of castings carries a serious risk of silicosis Studies of the dust conditions in a blasting chamber are described by K L Goodall in Chapter VIII They revealed that dust cloud concentrations

culosis the average length of exposure in sand and shotblasters was 6 3 years compared with 32 years for the other occupations

CONCLUSIONS

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castings are being treated The figures in our series are, however too s[m]all to be statistically reliable

... dence and the results of

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of the stringent regulations concerning dust control

(5) No definite evidence has been obtained as to whether shot blasting is less productive of cases of silicosis than sand blasting

FETTLERS OR CLEANERS OF CASTINGS

... of castings is done by a number of methods which

shot or

grinding

is not subject to similar regulations, though Inspectors of Factories have power under Section 47 of the Act to ask that it should be done under exhaust ventilation Technical difficulties connected with the varying sizes of castings have hitherto prevented the application of dust control methods The important point therefore about fettling of steel castings by pneumatic tools is that the fettlers or dressers have been exposed to the uncontrolled inhalation of freshly fractured particles of free silica dust In a few steel foundries the fettlers wear dust respirators On the other hand most other fettling or cleaning processes have been subject to dust control methods, which in some cases perhaps have not been highly efficient We therefore propose to deal first with the results of examinations of fettlers of steel castings

FETTLERS OR DRESSERS OF STEEL CASTINGS

As we pointed out in the review of the literature Middleton (1923) was the first to examine a group of steel fettlers and he came to the conclusion on clinical examinations only that though they showed evidence of the presence of pulmonary fibrosis and tuberculosis (22 8% and 6% respectively) they presented less lung damage than a group of metal grinders who used sandstone wheels At that time fettling was done mainly with hand tools, the pneumatic tool coming into more general use later Probably as a result of Middleton's work the idea arose that the dust from steel fettling was not highly dangerous but it is significant that when the silicosis compensation schemes came to be formulated, steel dressers (but not iron dressers) were scheduled as a group entitled to compensation for silicosis In our pathological investigation we have been able to examine the lungs of one steel dresser (Case 4) who had always used hand tools He died from coronary thrombosis and no silicosis was found in his lungs

Landau (1932, 1933) in Germany first drew attention to the risk in the fettling of castings with pneumatic tools and he found that 66% of 126 men had silicosis and 8% open tuberculosis Those engaged on steel castings were more severely affected with silicosis and tuberculosis than dressers of iron castings, though the risk in the latter was a definite one Evang in Norway found that in a small

records of the Factory Department and the Silicosis Medical Board (Chap VI) that the number of cases of silicosis and tuberculosis in this occupation has increased year by year since 1931. Records of 81 deaths and 199 other cases were obtained Altogether there were 364 applications to the Silicosis Medical Board for disablement certificates between 1931 and 1947 and of these 177 were refused.

The results of our investigation are given in Chapter IV and in Tables VI and VII Of 240 steel fettlers examined 51 per cent had normal chests, 19 per cent early reticulation, 25 per cent reticulation and 5 per cent had nodulation. The last two groups combined (73 cases or 30 per cent) can be regarded as

Some of the abnormal shadows are doubtless due to deposits of iron dust in the lungs, analysis of the dust having shown that a good deal of it consists of free silica and a smaller proportion of iron oxide It is interesting to speculate what part the presence of iron dust plays in delaying the onset of silicosis, seeing that Kettle (1932) ([103]) found experimentally that iron, like aluminium, acted as an antidote to the fibrosis-producing properties of free silica The fact remains, however, that fettlers of steel castings do contract silicosis, though not as rapidly as sandblasters do If in practice iron acts as an antidote there is not

accompanied by tuberculosis was found in 5 cases, in 15 cases there was silicosis and tuberculosis and in another case there was no silicosis, the cause of death being coronary thrombosis In the 15 cases with silico-tuberculosis the silicosis was advanced in 13 and slight in 2 cases

Chemical analyses of the lungs were made in 12 of these cases · the *ash* varied from 3 95 to 8 per cent of the dried weight of the lungs the percentages of *total silica* ranged from 0 47 to 1 81 and the *free silica* from 0 45 to 1 22 but

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the X-ray and histological appearances of

ray picture of reticulation, small silicotic

X-ray nodulation appears to correspond

necessary, therefore, to have X-ray nodu-

can be made

the lungs Photographs of the dust clouds arising from steel fettling are given on Fig 49 facing page 216 and representative dust counts show an average concentration of 12 800 particles per cubic centimetre

CONCLUSIONS

(1) Fettlers of steel castings are exposed to a serious risk of silicosis often accompanied by tuberculosis

(2) Well marked X ray reticulation appears after about 10 years exposure and in one factory all cases with 20 years exposure to the dust had X ray nodulation A diagnosis of silicosis can be made in the stage of reticulation when clinical evidence supports such a diagnosis

(3) In a series of 21 deaths in steel fettlers the average age at death was 53 4 years and the average duration of employment was 28 6 years

(4) Fettling with the pneumatic tool appears to be the most dangerous method because at present the dust is uncontrolled Hand fettling (with hammer and chisel) is much less dangerous

(5) It has not been possible to separate the grinders of steel castings from the fettlers but there is less risk of silicosis amongst them because most grinding processes are done under exhaust ventilation Artificial abrasive wheels are now used instead of sandstone wheels for grinding and thereby the silicosis risk has been greatly diminished

(6) The statistical evidence suggests that steel fettlers are more liable than others to develop abnormal X ray shadows in the lungs which on the clinical pathological and environmental evidence can be regarded as due mainly to silicosis

(7) The onset of silicosis is probably later in steel fettlers than it is in sand or shot blasters

chisel and (iii) that the output of steel castings is increasing

FETTLERS OF IRON CASTINGS

At the present time fettlers of iron castings are not eligible in this country to

did in fact contract silicosis but not to the same extent as steel fettlers The latter also were more liable to contract tuberculosis Hedenstedt (1940) in Sweden also found silicosis in cleaners of iron castings and out of 26 men examined 16 had silicosis and 2 had silico tuberculosis

developing abnormal X ray shadows was much less the corresponding ratios for steel fettlers in X ray Categories III and IV being 311±21

in 4 cases (2 advanced and 2 slight) One of these cases also had carcinoma of
ionia But the most
pigment associated
in type In some
cases this fibrosis was arranged in roughly nodular formation the pattern being radial rather than the whorled appearance of the classical silicotic nodule This mixed dust pneumoconiosis or modified silicosis was found in 5 out of *the 7 cases and in the remaining two classical silicotic nodulation dominated* the histological picture

Chemical analysis of the lungs was made in only 2 of these cases the ash being 7 1 and 6 22 per cent respectively of the dry weight whereas the figures for total silica were 1 35 and 1 58 per cent of the dry weight The percentages of Fe_2O_3 were respectively 2 0 and 1 56

The cases of pulmonary disease in iron fettlers collected by the Factory *Department and the Silicosis Medical Board are detailed in Chapter VI* and the following is a brief summary —

Records of pulmonary d sease n 17 iron dressers or grinders were collected and of these
Another
d of
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e in

Results of a study of the dust concentrations in an iron foundry are given in
kers

app ars to be reflected in the pathology of iron dres
ch racteristic appearance s the peribronchial and perivascular fibrosis usually associ ted with a mixed dust pneumocon osis caused by dusts containing lower p rcentages of free silica than those usually found in trades in which classical s l cosis develops It will be noted however *that even in iron dressers* typical sil cosis is sometimes found

CONCLUSIONS

(1) Iron fettlers are exposed to the inhalation of dust which in some cases can cause typical silicosis but more often produces a modified silicosis or a mixed dust pneumoconiosis

(2) The pneumoconiosis or modified silicosis of iron fettlers may be accompanied like typical silicosis by tuberculosis or by pneumonia either of which may be the immediate cause of death

the figures are suggested as representing approximately the relative risks of the two occupations

adequacy of dust control methods

MOULDERS

Methods of mould making are discussed in Chapter II A moulder s ex

Some large moulds take a month to make whereas in some iron foundries where small castings such as boot sprigs and door and window hinges are made as many as 150 boxes of moulds may be made during a shift The moulders in the

below 10μ

In the published papers on foundry workers few specific references to the health risks of moulders are found Greenburg, Siegal and Ross Smith (1938) however, record that of 1,409 moulders 4 4 per cent had silicosis, 7 2 per cent had fibrosis and 0 7 per cent had tuberculosis These figures refer to both iron and steel moulders The percentage incidences of these pulmonary lesions amongst 224 chippers or fettlers are much the same as in the moulders, the figures being 4 8 per cent silicosis, 4 per cent fibrosis and 0 9 per cent tuberculosis

The results of our investigations of iron, steel and mixed iron and steel

STEEL MOULDERS

Of 224 steel moulders examined 65 per cent had normal chests, 25 per cent had early reticulation, 9 per cent had reticulation, and 1 per cent had nodulation

of

of

X ray category I = 89
X ray category II = 148±16
X ray categories III and IV = 101±21

Only one steel moulder is included in the pathological investigations and he had suffered from cardiac enlargement with hypertension for 16 years before his death At necropsy broncho-pneumonia, bronchiectatic abscesses and

and steel fettling the

sses are

given in

X ray Category	*Moulding Shop*	*Fettling Shop*
Normal I	75 cases (65 8 per cent)	39 cases (42 per cent)
Early Reticulation II	18 cases (15 8 per cent)	13 cases (14 per cent)
Reticulation III	18 cases (15 8 per cent)	27 cases (29 per cent)
Nodulation and Massive Shadows IV	Nil cases (0 per cent)	12 cases (12 9 per cent)
Tuberculosis	3 cases (2 6 per cent)	2 cases (2 1 per cent)
Total	114 cases	*Total* 93 cases

(III and IV combined) were 15 8 per cent in the
In the moulding shop there were
ssive shadows whereas there were
p with this severe type of change

silicosis

CONCLUSIONS

series

(3) The statistical analysis shows that the percentage incidence of severe

shown by the statistical inquiry

(6) Steel moulders are subject to less pulmonary illness than are steel fettlers.

IRON MOULDERS

X-ray category I = 106
X ray category II = 106 ± 13
X-ray categories III and IV = 64 ± 15

Details of pathological ... of the ...

Chapter V

made and

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associated with classical and well marked silicosis Typical silicosis was present also in 3 more cases, in 2 of which there was also some bronchiectasis and emphysema and in the third lobar pneumonia In the remaining two cases there was a mixed dust pneumoconiosis (peribronchial and periarterial fibrosis)

In the published papers on foundry workers few specific references to the health risks of moulders are found Greenburg, Siegal and Ross Smith (1938) however, record that of 1,409 moulders 4 4 per cent had silicosis, 7 2 per cent had fibrosis and 0 7 per cent had tuberculosis These figures refer to both iron and steel moulders The percentage incidences of these pulmonary lesions amongst 224 chippers or fettlers are much the same as in the moulders, the figures being 4 8 per cent silicosis, 4 per cent fibrosis and 0 9 per cent tuberculosis

The results of our investigations of iron, steel and mixed iron and steel moulders are given in Tables IV and V The figures show that steel moulders are more liable to develop abnormal X-ray changes than iron or mixed iron and steel moulders In only one of the iron foundries investigated were very small castings made and here the incidence of silicosis was high

STEEL MOULDERS

Of 224 steel moulders examined 65 per cent had normal chests, 25 per cent

X ray category I = 89
X ray category II = 148±16
X ray categories III and IV= 101±21

cent, all figures being percentages of the dry weight of the lungs No cases of silicosis with or without tuberculosis appear in the records of the Factory Department or the Silicosis Medical Board

To illustrate the relative health risks of steel moulding and steel fettling the experience at Factory M may be cited In this factory the two processes are done in separate shops The numbers of cases in each X ray group are given in the following list —

X ray Category	*Moulding Shop*	*Fettling Shop*
Normal I	75 cases (65 8 per cent)	39 cases (42 per cent)
Early Reticulation II	18 cases (15 8 per cent)	13 cases (14 per cent)
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Tuberculosis	3 cases (2 6 per cent)	2 cases (2 1 per cent)
Total	114 cases	*Total* 93 cases

The severe abnormalities (III and IV combined) were 15 8 per cent in the moulding shop and 41 9 in the fettling shop In the moulding shop there were no cases showing X ray nodulation and massive shadows whereas there were 12 cases or 12 9 per cent in the fettling shop with this severe type of change

series

CONCLUSIONS

(1) Steel moulders are exposed to the inhalation of dust which after a period

series

(3) The statistical analysis shows that the percentage incidence of severe

IRON MOULDERS

nodulation The observed expected ratios are —

X ray category I	— 106
X-ray category II	= 106 ± 13
X-ray categories III and IV	— 64 ± 15

Details of pathological studies of the lungs of 8 iron moulders are given in Chapter V and 3 of these had worked at Factory K where small castings are made and silica parting powders used Their ages at death ranged from 32 to 63 years, the average being 48 9 years, whereas their length of employment at iron moulding varied from 13 to 50 years with an average of 28 1 years Pulmonary tuberculosis was present in 3 of the 8 cases and in each case it was associated with classical and well marked silicosis Typical silicosis was present also in 3 more cases, in 2 of which there was also some bronchiectasis and emphysema and in the third lobar pneumonia In the remaining two cases there was a mixed dust pneumoconiosis (peribronchial and periarterial fibrosis)

In the published papers on foundry workers few specific references to the health risks of moulders are found Greenburg, Siegal and Ross Smith (1938) however, record that of 1 409 moulders 4 4 per cent had silicosis 7 2 per cent had fibrosis and 0 7 per cent had tuberculosis These figures refer to both iron and steel moulders The percentage incidences of these pulmonary lesions amongst 224 chippers or fettlers are much the same as in the moulders the figures being 4 8 per cent silicosis, 4 per cent fibrosis and 0 9 per cent tuberculosis

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STEEL MOULDERS

Of 224 steel moulders examined 65 per cent had normal chests 25 per cent had early reticulation 9 per cent had reticulation and 1 per cent had nodulation It is interesting to note that all 3 cases with nodulation came from the one steel foundry in which silica flour was used in the moulding mixture In some of the 24 cases with reticulation and in all those with nodulation, a diagnosis of silicosis is justified The observed/expected ratios for steel moulders are —

X ray category I	= 89
X ray category II	= 148±16
X ray categories III and IV	= 101±21

Only one steel moulder is included in the pathological investigations and he had suffered from cardiac enlargement with hypertension for 16 years before his death At necropsy broncho pneumonia, bronchiectatic abscesses and marked general emphysema were found There was also histological evidence [illegible] lar fibrosis) but [illegible]

Department or the Silicosis Medical Board

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moulding mixture Amongst the moulders at another steel foundry (P) where silica flour was used, there were 3 cases of X-ray nodulation, probably due to silicosis.

the use of parting powder has a bearing on the incidence of dust diseases amongst moulders This point was not considered in the statistical analysis

CONCLUSIONS

(1) Steel moulders are exposed to the inhalation of dust which after a period

series

(3) The statistical analysis shows that the percentage incidence of severe X-ray abnormalities is greater amongst moulders in steel works than in iron or mixed iron and steel foundries

(4) This result is at variance with the detailed information about individual

IRON MOULDERS

X-ray category I	— 106
X-ray category II	— 106 ± 13
X-ray categories III and IV	— 64 ± 15

Details of pathological studies of the lungs of 8 iron moulders are given in Chapter V and 3 of these had worked at Factory K where small castings are made and silica parting powders used Their ages at death ranged from 32 to 63 years, the average being 48 9 years whereas their length of employment at iron moulding varied from 13 to 50 years with an average of 28 1 years Pulmonary tuberculosis was present in 3 of the 8 cases and in each case it was

the immediate cause of death in one being lobar pneumonia and in the other carcinoma of the stomach. Mixed dust pneumoconiosis was also found in some of the cases with classical silicosis, and in one instance, typical silicotic nodules, tuberculo-silicotic nodules and mixed dust pneumoconiosis were found in the same lung

1 86

In the records of the Factory Department and the Silicosis Medical Board (Chapter VI) are given details of 10 cases of lung disease in iron moulders There were 6 deaths from silicosis and 5 from silicosis and tuberculosis in the period between 1931 and 1946 inclusive In addition 16 non-fatal cases of silicosis and pneumoconiosis with or without tuberculosis were found between 1937 and 1944

CONCLUSIONS

(1) Iron moulders develop well marked silicosis and mixed dust pneumoconiosis

(2) It is likely that the incidence of these conditions is mainly associated with the repeated use and inhalation of the dust of silica parting powders But it has not yet been proved that the inhalation of the dust of parting powders is the only cause of the condition, because moulders are also exposed to other sources of dust, as for instance that arising from the knocking out of the sand

the larger the casting the less often are moulders exposed to the inhalation of dust clouds either from the application of parting powders or the knock out of sand moulds

FURNACEMEN

This group includes casters, ladlemen, pourers, cupola attendants and annealers In foundries the melting furnaces are usually situated in the moulding shop so that the molten metal may be taken rapidly to the moulds for pouring In some modern iron foundries the cupolas are situated outside the shop but are tapped inside Furnacemen are exposed to the inhalation of smoke and fume arising from the furnaces and also to the dust in the general atmosphere of the shop A good deal of the fume arising from melting furnaces consists of iron oxide

Few references to the health risks of furnacemen are found in the literature apart from some relating to the occurrence of infra-red cataract, to pneumonia, cancer and heat cramps No references have been found to the incidence of pneumoconiosis amongst them Again no records of lung disease in furnacemen have been found in the files of the Factory Department and the Silicosis Medical Board

cent) had early reticulation and 13 (20 per cent) had reticulation and 1 had nodulation In mixed iron and steel foundries 23 (82 per cent) out of 28 furnacemen had normal chests and 5 (18 per cent) had early reticulation There were no cases of reticulation or nodulation

The observed/expected ratios are given in Table V and except for X ray category I (normal) are regarded as unreliable on account of the small numbers involved For iron furnace workers the figures are —

X ray category I	92
X ray category II	(173 + 44)
X ray categories III and IV	(33 57)

For steel furnace workers the ratios are —

X ray category I	83
X ray category II	(121 28)
X ray categories III and IV	(159 34)

and for mixed iron and steel —

X ray category I	11?
X ray category II	(120 49)
X ray categories III and IV	(0 56)

640 particles per cc

CONCLUSIONS

(1) Furnace workers including casters ladlemen pourers cupola attendants and annealers develop after some years abnormal X ray appearances due to the inhalation of dust In only 1 out of 124 furnacemen was there an X ray picture of nodulation

be ruled out

KNOCK OUT MEN SANDMIXERS AND CRANE DRIVERS

the immediate cause of death in one being lobar pneumonia and in th oth carcinoma of the stomach Mixed dust pneumoconiosis was also found in sor of the cases with classical silicosis and in one instance, typical silicotic nodule, tuberculo silicotic nodules and mixed dust pneumoconiosis were found in th same lung

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(2) It is likely that the incidence of these conditions is mainly associated w th the repeated use and inhalation of the dust of silica parting powders But it has not yet been proved that the inhalation of the dust of parting powders is the only cause of the condition because moulders are also exposed to othe sources of dust as for instance that arising from the knocking out of the sand moulds Before the point can be settled one way or the other groups of iron ... mined ... uld ... the

... inci ... s ze of ... ecause ... on of ... k out

FURNACEMEN

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Few references to the health risks of furnacemen are found in the literature apart from some relating to the occurrence of infra red cataract to pneumon a cancer and heat cramps No references have been found to the incidence of pneumoconiosis amongst them Again no records of lung disease in furnacemen have been found in the files of the Factory Department and the S lco s Medical Board

... 30 of them in iron ... The results are ... 20 (67 per cent)

had normal chests, 9 (30 per cent) had early reticulation and 1 (3 per cent) had definite reticulation There were no cases with X-ray nodulation In steel

The observed/expected ratios are given in Table V and except for X ray category I (normal) are regarded as unreliable on account of the small numbers involved For iron furnace workers the figures are —

X-ray category I	92
	(173 - 44)
	(33 - 57)
X-ray category I	83
X-ray category II	(121 - 28)
X ray categories III and IV	(159 34)
and for mixed iron and steel —	
X ray category I	112
X ray category II	(120 49)
X-ray categories III and IV	(0 56)

It will be seen that steel furnace workers show a higher incidence of severe X ray abnormalities than iron or mixed iron and steel workers No furnace workers appear in the pathology section and we are therefore unable to state

shadows are thrown by deposits of iron oxide in the peribronchial and perivascular lymph spaces (siderosis) Clinically there was little evidence of disability amongst the furnacemen but it is possible that some of them might develop a mixed dust pneumoconiosis or even silicosis The question will have to be decided when opportunity arises for histological examinations In a dust survey in Iron Foundry W it was shown that workers around the cupolas and ladle pouring sections were exposed to dust concentrations of between 270 and 640 particles per cc

CONCLUSIONS

(1) Furnace workers, including casters, ladlemen, pourers, cupola attendants and annealers develop after some years abnormal X ray appearances due to the inhalation of dust In only 1 out of 124 furnacemen was there an X-ray

be ruled out

KNOCK-OUT MEN, SANDMIXERS AND CRANE DRIVERS

fibrosis, the percentages being —

	Silicosis	Fibrosis	Tuberculosis
Chippers	4 8	4 0	0 9
Knock out labourers	0 5	2 8	1 0

No correction was made however for age and length of exposure These investigators also found no cases of silicosis amongst 69 crane drivers, though 4 4 per cent of them had fibrosis

Our figures for knock out men, sandmixers and crane drivers were as follows — of 37 men so employed in *iron foundries* 32 (87 per cent) *had normal chests*

normal X-ray pictures

The observed/expected ratios for this group are given in Table V and they

reticulation) in steel workers is regarded as reliable, but that for X ray categories III and IV is not reliable The ratios are repeated here for convenience

Iron	X-ray category I	= 117
	X-ray category II	= (62±39)
	X ray categories III and IV	= (31±56)
Steel	X-ray category I	= 80
	X-ray category II	= 160±28
	X ray categories III and IV	= (112±34)
Mixed	X ray category I	= 124
	X ray category II	= (0±60)
	X-ray categories III and IV	= (0±96)

The ratios in brackets are regarded as unreliable

On page 140 will be found details of a case of silicosis in a man engaged for most of his working life as a "mucker out" in a steel foundry *This job is* comparable with the knock out The diagnosis of silicosis was made on clinical and radiographic evidence

It is likely that crane drivers in fettling shops develop more X-ray abnormalities than those in moulding shops In Factory M for instance 3 fettling shop and 4 moulding shop crane drivers were examined Those in *the fettling* shop all showed well marked X ray reticulation (2 in the 6 – 10 years exposure group and 1 in the 16 – 20 group) Of the 4 moulding shop workers, 2 (6 – 10

and welders

CONCLUSIONS

silicosis or mixed dust pneumoconiosis

MOULDING SHOP LABOURERS

This group includes in addition to labourers slingers, truck drivers and internal dispatch men The group is more or less homogeneous in that they are exposed to inhalation of dust in the general atmosphere of the shops and not as in other groups such as blasters fettlers and welders to high concentrations

11 (12 per cent) had early reticulation and 9 (10 per cent) had reticulation Again there were no cases with nodulation As regards mixed iron and steel foundries 58 (92 per cent) out of 63 men had normal chests, 4 (6 per cent) had early X ray reticulation and 1 (2 per cent) had reticulation None had nodulation

the pathological series nor are there details of cases of pneumoconiosis in the files of the Factory Department and the Silicosis Medical Board

CONCLUSIONS

(1) Moulding shop labourers, slingers, truck drivers and internal dispatch men develop X-ray abnormalities due to dust inhalation

(2) The incidence is significantly high for early reticulation (II) in mixed iron and steel workers in this group For the severer forms of X-ray abnormality (reticulation and nodulation) the incidence is low in iron, steel and mixed iron and steel foundries

(3) Definite silicosis has not been found in any man with a clear occupational history of having been only a moulding shop labourer

(4) It is possible that the abnormal X-ray changes found might represent the early stages of silicosis, mixed dust pneumoconiosis or siderosis but we have no pathological evidence to support or disprove this theory

VARIOUS OCCUPATIONS IN THE MOULDING SHOP

The results of examination of this group which includes those men who have done so many different jobs in the moulding shop that they could not be classi- [illegible]

further because the results are not of much value in the determination of the health risks of specific occupations

FETTLING SHOP WORKERS

The results of examinations of iron and steel fettlers and shotblasters have been discussed above It now remains to deal with other occupations in the fettling shop

(1) *Welders* This group includes electric arc welders, oxyacetylene welders, burners and cutters Because the numbers examined were too small to be [illegible] they have been combined in Tables VI and VII with [illegible] e figures for shotblasters are given in [illegible] are subtracted from the welders and [illegible]

Type of Exposure	No of Workers X ray Groups I	II	III	IV	Percentage of all X ray Groups X ray Groups I	II	III	IV
Iron	4	—	—	—	100	—	—	—
Steel	31	15	22	9	40	19	29	12
Mixed	12	5	1	—	66	28	6	—

Th[illegible] not a satisfactory grouping because though welders and labourers [illegible]

It will be seen that welders [illegible] incidence of abnormal X ray changes when compared with *similar groups in* iron and mixed iron and steel foundries The observed/expected ratios however

are not reliable because the figures are too small for adequate statistical treatment. The ratios for the whole group of welders, shotblasters and labourers, are however given in Table VII but except for steel workers the ratios are unreliable. Those for the steel workers of this group are —

I (normal)	*II (early reticulation)*	*III and IV (Reticulation and Nodulation)*
57	118±25	361±31

The abnormal X-ray appearances in welders and other workers who inhale iron oxide dust have received a great deal of attention since 1936 when Doig and McLaughlin first drew attention to the condition. It has been shown that the abnormal X-ray shadows are thrown by deposits in the lungs of iron oxide which is opaque to X rays. The condition is called welders' siderosis, a form of pneumoconiosis classified as "benign" because the iron oxide dust does not set up fibrosis and the welders show little or no disability. Post mortem studies on a welder by Enzer and Sander (1938) and animal experiments by Harding (1945) and Harding, Grout and Lloyd Davies (1947) have shown conclusively that iron oxide in its pure form does not cause fibrosis. Further studies by McLaughlin, Harding and others have shown that iron oxide when inhaled by workers in other occupations produces similar X-ray appearances with no disabling clinical features. Finally Doig and McLaughlin (1948) have carried the study of welders' siderosis a step further by showing that the iron oxide dust can be slowly eliminated from the lungs and that the abnormal X-ray

to siderosis

In our pathological series (Chapter V) is described the case (No 19) of a carbon arc welder aged 55 years who had worked for 34½ years at welding of steel castings in a steel fettling shop. In his early working career he had worked

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ated with these aggregates were varying degrees of linear fibrosis of the collagenous type. The ash and iron contents of the lung were very high (14 2 and 10 7 per cent respectively of the dry weight). It is clear that this welder had

CONCLUSIONS

(1) Moulding shop labourers, slingers, truck drivers and internal dispatch men develop X ray abnormalities due to dust inhalation

(2) The incidence is significantly high for early reticulation (II) in mixed iron and steel workers in this group For the severer forms of X ray abnormality (reticulation and nodulation) the incidence is low in iron, steel and mixed iron and steel foundries

(3) Definite silicosis has not been found in any man with a clear occupational history of having been only a moulding shop labourer

(4) It is possible that the abnormal X ray changes found might represent the early stages of silicosis, mixed dust pneumoconiosis or siderosis but we have no pathological evidence to support or disprove this theory

VARIOUS OCCUPATIONS IN THE MOULDING SHOP

further because the results are not of much value in the determination of the health risks of specific occupations

FETTLING SHOP WORKERS

The results of examinations of iron and steel fettlers and shotblasters have been discussed above It now remains to deal with other occupations in the fettling shop

(1) *Welders* This group includes electric arc welders oxyacetylene welders, burners and cutters Because the numbers examined were too small to be treated statistically they have been combined in Tables VI and VII with labourers and shotblasters The separate figures for shotblasters are given in addenda to these tables When these are subtracted from the welders and labourers the figures for the latter are —

Type of Exposure	No of Workers				Percentage of all X ray Groups			
	X ray Groups				X ray Groups			
	I	II	III	IV	I	II	III	IV
Iron	4	—	—	—	100	—	—	—
Steel	31	15	22	9	40	19	29	12
Mixed	12	5	1	—	66	28	6	—

This is still not a satisfactory grouping because though welders and labourers

I (normal)	*II (early reticulation)*	*III and IV (Reticulation and Nodulation)*
57	118±25	361±31

McLaughlin, Harding and others have shown that iron oxide when inhaled by workers in other occupations produces similar X-ray appearances with no disabling clinical features. Finally Doig and McLaughlin (1948) have carried the study of welders' siderosis a step further by showing that the iron oxide dust can be slowly eliminated from the lungs and that the abnormal X-ray shadows will disappear when the worker gives up welding and no more fume is inhaled. When less welding is done the abnormal shadows will diminish in

of siderosis in oxyacetylene cutters and Hamlin (1947) 4 cases in foundry grinders and burners. In all three series the men worked in rooms where there was also exposure to free silica dust as well as to the iron oxide of the welding or cutting fume but the amount of silica dust was considered too low to cause silicosis.

to siderosis.

In our pathological series (Chapter V) is described the case (No. 19) of a carbon arc welder aged 55 years who had worked for 34½ years at welding of steel castings in a steel fettling shop. In his early working career he had worked for a year on grinding castings with a swing frame grinder. He died from subacute nephritis with cardiac failure, intercurrent bronchitis and broncho-pneumonia. Histological examination of the lungs showed that in one area there was a collection of rounded areas of fibrosis with some suggestion of whorling though not typically silicotic. In a lymph gland, however, typical

10.7 per cent respectively of the dry weight). It is clear that this welder had

mixed dust pneumoconiosis The risk appears to be less when the occupation

out of 19 workers had normal chests, 4 (21 per cent) had early reticulation and 1 (5 per cent) had reticulation Of 59 such workers in steel foundries 23 (39 per cent) were normal, 13 (22 per cent) were classified as early reticulation, 18 (30 per cent) as reticulation and 5 (9 per cent) as nodulation In mixed iron and steel foundries there were 48 workers in this group and 26 (54 per cent) of them had normal chests, 15 (31 per cent) had early reticulation, 6 (13 per cent) had reticulation and 1 (2 per cent) nodulation

There were two significant and reliable observed/expected ratios, one for the steel workers in X ray categories III and IV combined (reticulation and nodulation), 279±35, and the other for mixed iron and steel workers in X-ray category II, the ratio being 165±33 The other ratios (see Table VII) are regarded as unreliable but they suggest that comparable miscellaneous occupations in iron foundries are less productive of abnormal X-ray changes than in steel or mixed iron and steel foundries

COMPARISON OF RESULTS FOR MOULDING AND FETTLING SHOPS

an
Ta
tic
shop and 663 fettling shop workers The ratios are repeated here for convenience —

Type of Exposure		X ray Groups			
		I	II	III & IV	Total
Moulding shop workers (1,487)	Iron	107	104±10	55±11	100
	Steel	91	127±11	116±13	100
	Mixed	114	74±12	62±14	100
Fettling shop workers (663)	Iron	92	140±20	(90±23)	100
	Steel	65	116±12	317±15	100
	Mixed	89	137±21	(107±26)	100

From a study of these ratios the following conclusions may be drawn —

(2) Work in steel moulding shops is more productive of dust inhalation changes in the lungs (as shown by X-ray examination) than similar work in the moulding shops of iron or mixed foundries (The fallacy relating to the size of castings and the frequent use of silica parting powders in iron moulding [illegible]

[illegible]

the presence of the pneumoconioses, either silicosis, mixed dust pneumoconiosis (or modified silicosis) or siderosis.

CORESHOP WORKERS

This group consists of coremakers, core drying oven attendants and others who work in the coreshops Because coremakers work with oiled sand the coreshop is usually one of the least dusty departments in foundries In Keatinge and Potter's (1945) clinical and environmental studies of two iron foundries it was found that coreshop workers were exposed to a minimal risk of silicosis Mr. K. L. Goodall's dust survey in Iron Foundry W, which is the subject of Chapter VII, records only two measurements in a core-making section in which a boy core maker was found to be breathing 740 particles per cc of dust (median size 0 3μ) in a general atmosphere adjacent to the plant of 395 particles per cc. (median size 0 4μ)

In the present investigation 158 such workers were examined 52 of them worked in iron foundries and 48, (92 per cent) had normal chests, the remaining 4 (8 per cent) showing early reticulation. There were no cases with either marked reticulation or nodulation But of the 41 coreshop workers in steel foundries 32 (78 per cent) were normal, 7 (17 per cent) had early reticulation and 2 (5 per cent) had reticulation whereas none had nodulation In the mixed iron and steel foundries 55 (8 per cent) of 65 workers were normal, 8 (12 per cent) had early reticulation and 2 (3 per cent) had advanced reticulation The observed expected ratios (Table IX) show that the risk of pneumoconiosis as indicated by abnormal X-ray shadows is not great Information about lung disease in coreshop workers in the records of the Factory Department and the Silicosis Medical Board is scanty Only one coremaker appears in these records He worked at the job in an iron foundry for 33 years and died at 49 years of age from silicosis and tuberculosis, the diagnosis being confirmed by histological examination It appears that it was the practice in the foundry to dust the cores with waste dust from the sandblasting machine Another coremaker is described in Chapter V (Case 63) He had worked for 40 years in an iron foundry and died from broncho-pneumonia. There was also slight "mixed dust" pneumoconiosis but no silicosis

CONCLUSIONS

(1) Coremakers and other workers in coreshops in both iron and steel foundries are exposed only to a slight risk of silicosis and mixed dust pneumoconiosis

(2) The risk is greater if coremaking is not done in a shop separate from the main foundry and if the cores are dusted with a powder containing free silica

PATTERN SHOP WORKERS

As pointed out in the chapter on foundry processes the pattern shop in all foundries is completely separate from the moulding and fettling shops and normally the pattern makers are exposed only to the inhalation of wood dust.

developed a mixed dust pneumoconiosis with silicosis and siderosis as a result

mixed dust pneumoconiosis The risk appears to be less when the occupation is carried on in an iron fettling shop

out of 19 workers had normal chests 4 (21 per cent) had early reticulation and 1 (5 per cent) had reticulation *Of 59 such workers in steel foundries* 23 (39 per cent) were normal, 13 (22 per cent) were classified as early reticulation 18 (30 per cent) as reticulation and 5 (9 per cent) as nodulation In mixed iron and steel foundries there were 48 workers in this group and 26 (54 per cent) of them had normal chests, 15 (31 per cent) had early reticulation, 6 (13 per cent) had reticulation and 1 (2 per cent) nodulation

iron and steel foundries

COMPARISON OF RESULTS FOR MOULDING AND FETTLING SHOPS

s in the moulding an will be found in T. with due corrections for age and length of exposure on the examinations of 1,487 moulding shop and 663 fettling shop workers The ratios are repeated here for convenience —

Type of Exposure		X ray Groups			
		I	II	III & IV	Total
Moulding shop workers (1 487)	Iron	107	104±10	55±11	100
	Steel	91	127±11	116±13	100
	Mixed	114	74±12	62±14	100
Fettling shop workers (663)	Iron	92	140±20	(90±23)	100
	Steel	65	116±12	317±15	100
	Mixed	89	137±21	(107±26)	100

ies is work and

(2) Work in steel moulding shops is more productive of dust inhalation

CORESHOP WORKERS

This group consists of coremakers core drying oven attendants and others who work in the coreshops Because coremakers work with oiled sand the

and 2 (5 per cent) had reticulation whereas none had nodulation In the mixed iron and steel foundries 55 (8 per cent) of 65 workers were normal 8 (12 per cent) had early reticulation and 2 (3 per cent) had advanced reticulation The observed/expected ratios (Table IX) show that the risk of pneumoconiosis as indicated by abnormal X ray shadows is not great Information about lung disease in coreshop workers in the records of the Factory Department and the Silicosis Medical Board is scanty Only one coremaker appears in these records He worked at the job in an iron foundry for 33 years and died at 49 years of age from silicosis and tuberculosis the diagnosis being confirmed by histo

dust pneumoconiosis but no silicosis

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developed a mixed dust pneumoconiosis with silicosis and siderosis as a result of h s work in a s l... [illegible]

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ing sh [illegible]

mixed dust pneumoconiosis The risk appears to be less when the occupation is carried on in an iron fettling shop

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out of 19 workers had normal c[illegible]

1 (5 per cent) had reticulation [illegible]

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(30 per cent) as reticulation an[illegible]

and steel foundries there were 48 workers in this group and 26 (54 per cent) of them had normal chests 15 (31 per cent) had early reticulation 6 (13 per cent) had reticulation and 1 (2 per cent) nodulation

There were two significant and reliable observed/expected ratios one for the steel [illegible]

iron and steel foundries

COMPARISON OF RESULTS FOR MOULDING AND FETTLING SHOPS

It is interesting to compare the results of X ray examinations in the moulding and fettling shop workers The observed/expected ratios will be found in Tables V and VII respectively and th[illegible] tions for age and length of exposure [illegible] shop and 663 fettling shop workers [illegible] ence —

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	Steel	65	116±12	317±15	100
	Mixed	89	137±21	(107±26)	100

[illegible] be drawn —

[illegible] mixed foundries is [illegible] hanges than work [illegible] he severe (III and

(2) Work in steel moulding shops is more productive of dust inhalation changes in the lungs (as shown by X ray examination) than similar work in the moulding shops of iron or mixed foundries (The fallacy relating to the size of castings and the frequent use of silica parting powders in iron moulding shops has been referred to previously)

(3) Work in steel fettling shops is associated with a higher incidence of severe X ray abnormalities than work in iron or mixed fettling shops

(4) The highest ratio 317±15 relates to severe X ray abnormalities contracted in steel fettling shops

(5) In general the abnormal X ray shadows may be interpreted as indicating the presence of the pneumoconioses either silicosis mixed dust pneumoconiosis (or modified silicosis) or siderosis

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PATTERN SHOP WORKERS

As pointed out in the chapter on foundry processes the pattern shop in all foundries is completely separate from the moulding and fettling shops and normally the pattern makers are exposed only to the inhalation of wood dust

Apart from this the young worker is less likely to avoid making unnecessary dust clouds or inhaling the dust

The [illegible]
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to be n
young
that the X ray changes may be due partly to the formation of fibrous tissue either of the silicotic or mixed dust pneumoconiotic types

INCIDENCE OF PNEUMONIA

Zacks (1935) found that it was the greatest occupational health risk in the foundry industry in Massachusetts and that the mortality rate from this cause was three times greater than in granite workers or in the general population McConnell and Fehnel (1934) quoting insurance company statistics, showed that in America there was a high incidence of respiratory diseases amongst foundrymen and that pneumonia was the most common immediate cause of death Other American work refers to the high incidence of pneumonia in the shipbuilding industry and amongst those who work out of doors or are exposed to great heat

In this country the most significant evidence on the point com s from the Registrar General s Decennial Supplement for 1931 ([81]) on occupational mor tali.y He showed that certain groups of workers in the iron and steel trades had an excessive mortality rate for respiratory diseases other than tuberculosis compared with the standardised mortality ratio (S M R) for all occupied males The following groups show an excess mortality from this cause —

- Furnacemen Rollers and their skilled assistants (unskilled assistants also had a high pneumonia rate)
- Puddlers (iron and steel)
- Metal moulders and casters
- Foundry furnacemen and casters
- Iron and steel foundry labourers
- Metal grinders

On the other hand annealers softeners, hardeners and temperers of metal showed no excess in the S M R *but there was an excess in deaths from influ enza* Electric welders and cutters showed no excess in the S M R *from any* cause

[illegible] that the w ves of men in such groups as metal
greater excess of
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nding order —

- Tin and copper mine workers below ground
- Other metalliferous mine workers below ground
- Stevedores
- Potters ware makers, casters and finishers
- Kiln and oven men (earthenware china, terra cotta)
- Glazers, polishers, buffers and moppers
- Cotton strippers and grinders
- Iron foundry furnacemen and labourers

It will be seen therefore that foundrymen come a good way down the list, though sandblasters who head it may work in foundries as well as in other types of factories. Collis (1919) [15] has shown statistically that workers exposed to the inhalation of free silica or quartz dust have a high incidence of respiratory diseases in addition to silicosis and tuberculosis. The trades listed above nearly all have a silicosis risk, the exceptions being stevedores and cotton strippers and grinders.

Keatinge and Potter (1945) [33] in a study of 219 English iron foundry workers showed that of every 100 of them 26.9 suffered from respiratory illnesses and lost 492 working days from this cause, while in a control group of 282 men engaged on constructional work the comparable figures were 39.2 cases who lost 417 working days. Fewer foundrymen suffered from respiratory illnesses but lost more working time than did the constructional group. It was not stated how many of these had pneumonia.

A survey of the incidence of pneumonia in Sheffield during 1940 was carried out by one of us (A. I. G. McL.) and it was found that there were 27 cases per 10,000 amongst steel workers as compared with 38.9 per 10,000 in the general population, that the mortality rate was lower in steel workers than in the general population and that the case mortality amongst housewives was higher than that of the steel workers — 19.7 per cent as opposed to 17.9 per cent.

It is obvious that many factors such as climate, temperature, season of year, atmospheric pollution of industrial towns, housing, income, diet, virulence of infection, age and physical constitution enter into a study of the causes of pneumonia and it is not possible to deal with the subject exhaustively in this report.

We have made a partial inquiry on the point and the results are given in Chapter IV. Briefly, of 2,735 iron and steel foundry workers, 140 (5 per cent) gave a history of having had pneumonia. An attempt to correlate the incidence of pneumonia with the X ray appearances of the lungs showed interesting trends which appear to call for more detailed study of larger groups and controls from other occupations. In steel foundries for instance we found that a worker whose X-ray film showed reticulation or nodulation was less likely to have had an attack of pneumonia than another who showed less severe lung changes. Our studies of the pathology of foundry workers' lungs suggest that pneumonia is not the most common immediate cause of death amongst them.

On the present evidence it is doubtful whether pneumonia should be regarded as an occupational disease of foundry workers, at least in this country. It must be admitted, however, that work in foundries contains factors, such as exposure to extremes of heat and cold and to dust and fume which play an important part in the causation of pneumonia. But undoubtedly the prime cause of pneumonia is infection of the respiratory tract by virulent bacteria or viruses.

CANCER

The Registrar-General (1938) [84] has shown that there was an excess of cancer of all sites in furnacemen rollers and their skilled assistants, in metal moulders and die casters, in iron and steel foundry labourers and in metal grinders. In all 4 groups there was an excess incidence of cancer of the lung, the highest occurring in metal moulders and die casters. Midgley Turner and Grace (1938) [62] in a study of the cancer mortality among males in certain Sheffield trades came to the conclusion that in six occupational groups there was a significantly greater mortality from cancer than that experienced by clerks, business and professional men in the town. The six groups were —

1 Engineers machinists cutlers etc
2 Steel foundry and furnace workers etc
3 Grinders and sandblasters
4 Workers in precious and non ferrous metals
5 Workers in transport and communications
6 Coal miners

In the first 3 groups they thought that the excess cancer was definitely associated with the occupations Cancer of the tonsil was particularly excessive amongst steel workers and cancer of the respiratory tract was marked in engineers foundry workers and grinders and in no other occupational group The highest incidence of cancer of the alimentary tract was found in foundry and furnace workers and they suggested that the carcinogenic factor might be the ingestion of hydrocarbons from fumes and smoke Cancer of the pancreas was excessive only in engineers and in workers in non ferrous metals whereas cancer of the skin was significantly excessive in foundry workers and in engineers

All that we can add to these findings at the present time is that during our clinical and X ray examinations of 3 059 foundry workers in 19 foundries in different parts of the country we found no cases of cancer of the lung throat or skin In our pathological studies of 64 foundry workers lungs we found 3 cases of cancer of the lung

PREVENTIVE MEASURES

The problem of the prevention of industrial lung diseases amongst foundry workers when reduced to its simplest terms consists in seeing that no dust gets into the air of the workrooms to be inhaled by the workers This is a counsel of perfection because foundry processes are inherently dusty and few dust ... completely efficient The whole subject of dust pre ...

... blems which ... le to general ... As regards ... d by a Joint ...

the improvement of conditions in iron foundries ... mittees contain much information on methods of dust suppression in individual foundry processes

... of the pneumoconioses including sili ...

used with success as a mould paint appea ...

olivine and zircon have to be imported and their cost is rather high compared
with that of sand Experiments with serpentine (a material like ol
there are deposits in the Highlands have not bee
are being made with serpentine d
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be used as a constituent ommended that steel foundries has been used with quantities of suitable alternative non-siliceous ... "no material containing free silica should ... The Committee on Dust ... will be
periments are also being carried out to find a non siliceous materials are available" Ex-

be used as a constituent of steel moulding compositions as soon as sufficient quantities of suitable alternative non-siliceous materials are available" Experiments are also being carried out to find a non siliceous material instead of silica sand for coremaking Efficient non-siliceous substitutes, such as dolomitic limestone and sillimanite, have now been found to replace the silica flour of which parting powders hitherto have been composed It has also been found practicable to replace the silica in mould paints by such non-siliceous materials as sillimanite, zircon and calcined alumina Many practical foundry men consider that there is no need to use silica flour at all in foundries and are of the opinion that its use should be prohibited The use of steel shot or grit instead of sand in blasting operations is now a common practice and the Committee on Dust in Steel Foundries has recommended that the use of sand be prohibited for this purpose * But the risk of silicosis is not entirely eliminated by the use of steel shot because dust containing free silica arises from the adherent sand on the casting which is being blasted

The substitution of non siliceous materials for those containing free silica will result in a diminution or even the abolition of the risk of silicosis but the processes will still be dusty The second principle of prevention of industrial lung diseases is to see that the dust does not get into the air of the workroom The main methods of dust suppression are (a) enclosure of the dusty process, (b) removal of the dust by exhaust ventilation as near as possible to the point of origin of the dust and (c) attention to the general ventilation of the workrooms Enclosure of the process and exhaust ventilation may with advantage be combined The details of design of fans, hoods and ducts of dust extraction plant depends on the circumstances of each process, and are matters for the expert ventilating engineer The efficiency of the exhaust system can be controlled by periodic estimations of the airborne dust There are few dusty processes to which exhaust ventilation cannot be successfully applied Fettling of castings with pneumatic hammers is one foundry process which has not lent itself readily to the application of exhaust ventilation particularly in those foundries in which castings of varying sizes and shapes are made The castings are widely spread over large floor areas, and work is carried on over all parts of the castings and at many different angles Experiments are being made to investigate the possibility of dealing with the smaller castings at work benches provided with mechanical exhaust and of applying exhaust ventilation by means of movable hoods to the fettling of larger castings The matter is urgent because as is shown elsewhere in this report the incidence of silicosis amongst fettlers of steel castings is high

In some processes the evolution of dust may be prevented by wet methods For instance, much of the dust arising during the knocking-out of castings from the sand moulds and cores may be prevented by injecting water mixed with a wetting agent into the moulds and cores The blasting of castings with a powerful jet of water also has the effect of allaying much of the dust associated with

*Since this was written, the Blasting (Castings and Other Articles) Special Regulations have been issued (1949 No 2225) and prohibit the use of sand in blasting operations

1

the knock out though the process was originally introduced for the cleaning of castings and to eliminate shotblasting and fettling with pneumatic tools

Another principle of prevention is that dusty processes such as the knock out and fettling of castings should be separated from other processes or where th s is not possible should be carried out only when small numbers of workers are present in the workrooms For instance in many foundries the knock out is done at night

As well as dust control methods the worker in some processes may protect

worker is compelled by law to wear a protective device against inhalation of dust Fettlers of castings are obliged to wear goggles to protect their eyes from flying particles but there is no regulation to compel them to wear dust respirators Some fettlers do in fact wear dust respirators for short periods during the working shift but it is not a common practice The Factory Department

air of the workrooms and so to render unnecessary the wearing of personal protective devices by the workers

methods instead of sweeping is recommended

ry atmospheres the general con sses and the application of ex the report of the Committee s should not be used for heating ying and the baking of moulds

of prevention of irritating fumes from core bonding materials is now recei attention and involves many *technical considerations* which cannot be discussed here

Finally it is recommended that foundry workers be kept under regular medical supervision which should include pre employment and periodical X ray chest examinations

CHAPTER X

REPRESENTATIVE CASE HISTORIES

BY A I G McLAUGHLIN

The 40 cases described in this chapter have been chosen to
points abc
workers
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periods in
X-ray app
described.

Cases 1 – 26 are steel foundry workers and they have been del berate
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the effects
on which
be seen th ... much earlier and advance further in the fettlers than in the moulders

Case (1) Steel Moulder 6 months

Age 14½ years X ray No 1240

Occupational History Left school at 14 years of age began at a steel foundry as an apprentice moulder and had worked there for 6 months at the time of the examination

Family History Nil relevant except that his father works in the fettling shop of the same factory

Previous Health Good except for a number of the infectious ailments such as measles, and whooping cough

Present Health No cough, expectoration or shortness of breath

On Examination General nutrition good Chest measurements 29″ after deep inspiration 32″ after deep expiration 28″ Cardiac response to effort 80 136 92 E T T 1½ No abnormal physical signs in heart lungs or other systems

X-ray Examination (Plate XII) Completely normal chest

COMMENT This case illustrates the normal X ray appearances of the chest after only 6 months exposure to the dust conditions in a steel moulding shop

Case (2). Steel Moulder 6 years.

Age 22 years X-ray No 1216.

Occupational History. Left school at 14 years of age and went straight to a steel foundry where he first worked in the pattern shop for $2\frac{1}{2}$ years and then as a steel moulder for 6 years

Family History. Father, aged 63, who was a steel fettler at the same foundry has recently died from silicosis.

Previous Health No serious illnesses but has suffered from constipation, pains in the chest and headaches

Present Health No cough or dyspnoea but brings up black sputum after work He is a non-smoker

On Examination General nutrition good A highly strung youth Chest measurements $35\frac{1}{2}''$, after deep inspiration $37''$, after deep expiration $34''$. Cardiac response to effort 100 108 100 E.T.T. 1 No abnormal physical signs in heart, lungs or other systems

X-ray Examination (Plate XIII) Lung fields show some increased linear striation but the whole picture is within normal limits

COMMENT This case illustrates the slight X-ray changes which may be found after 6 years of exposure to the dust conditions in a steel moulding shop

Case (3). Steel Moulder 17 years.

Age 32 years X-ray No 1213

Occupational History Left school at 14 years of age, laundry work 1 year and then to a steel foundry as a moulder (17 years)

Family History Nil relevant

Previous Health Acute rheumatism 8 years ago, away from work 6 weeks

[illegible] onally [illegible] ng or [illegible]

COMMENT. To illustrate the slight X ray changes found after 17 years exposure in a steel moulding shop

Case (4) Steel Moulder 57 years.

Age 71 years X-ray No 1167

Occupational History Left school at 13 years of age, errand boy 1 year, then worked as a moulder at one steel foundry for 12 years and at another steel foundry for 45 years

Family History Nil relevant

Previous Health Had inflammation of the lungs in childhood and has suffered since from pains in the lower part of the back

Present Health Slight cough, no expectoration or dyspnoea at rest

On Examination Spare and rather pale, chest measurements 34", after deep inspiration 35", [illegible] 96, E T T 2 [illegible] cussion note [illegible] anteriorly and [illegible] other systems normal

X-ray Examination (Plate XV) Well marked reticulation both lung fields In addition to the reticulation there is a background of fine stippling

[illegible]

Case (5). Steel Moulder 48 years

Age 62 years X-ray No 1168

Occupational History Left school at 14 years of age, began work immediately as an apprentice moulder and has worked at moulding all his working life (48 years)

Family History Nil relevant

Previous Health No serious illnesses

Present Health Slight cough with occasional black sputum during and after work, slightly short of breath

[illegible]

X-ray Examination (Plate XVI) Emphysema both lung fields with generalised fine stippling

COMMENT A steel moulder of 62 years with 48 years experience shows of emphysema and dust inhalation has slight symptoms of disability.

Case (6). Steel Moulder 24 years.

Age 38 years X ray No 1264

Occupational History Left school at 14 years of age, became an apprentice moulder in a steel foundry and has worked at the same job in the same foundry all his working life (24 years)

Family History His twin brother also works as a moulder in the same foundry

Previous Health Influenza twice but no other serious illness

Present Health No cough or dyspnoea but brings up black sputum which he says is full of dust and sand Non-smoker

On Examination General n [illegible]

X-ray Examination (Plate XVII) Early reticulation both lung fields

COMMENT This case illustrates the early X-ray reticulation without symptoms or signs of disability which may be found after 24 years exposure to steel moulding

Case (7) Steel Moulder 27 years.

Age 41 years X ray No 1189

Occupational History Left school at 14 years of age and immediately became an apprentice steel moulder and has worked at it ever since (27 years)

Family History Nil relevant

Previous Health No serious illnesses

Present Health Complains of chronic morning cough and a series of colds for 8 or 9 years brings up sputum which is black, no dyspnoea

On Examination General nutrition good Chest measurements 35", after deep inspiration 36½", after deep expiration 34½" Cardiac response to effort 88 120 100 E T T 1 No abnormal physical signs over lung fields and none in the cardiac and other systems

X-ray Examination (Plate XVIII) Well marked reticulation over both lung fields

COMMENT Well marked X ray reticulation without disability – 27 years exposure

Case (8) Steel Moulder 23 years

Age 37 years X ray No 1228

Occupational History Left school at 14 years of age and became an apprentice moulder and has worked at the job ever since (23 years)

Family History Nil relevant

Previous Health Had catarrhal jaundice 1 year previously and was off work for six weeks This is his only illness since going to the foundry

Present Health Slight cough no dyspnoea and no sputum

On Examination General nutrition fair rather pale Chest measurements 34¼", after deep inspiration 36½" after deep expiration 33¾" Cardiac response to effort 82 120 108 E T T 1 The only abnormal physical signs in the chest are some crepitations in the left axilla towards the base of the lung the first heart sound is roughened and the second is accentuated

X ray Examination (Plate XIX) Increased linear striation with some early reticulation both lung fields

COMMENT Early X ray reticulation after 23 years exposure (Compare cases 6 and 7)

Case (9) Steel Moulder 46 years

Age 63 years X ray No 1164

Occupational History Left school at 14 years of age Farming for 2 years and then to a steel foundry as an apprentice moulder and has worked at the job ever since (46 years)

Family History Nil relevant

Previous Health Appendicitis 16 years previously Apart from this has been very well Played league cricket until the age of 60

Present Health No cough slight sputum does get a bit short of breath especially after running but not after walking

On Examination General nutrition good Chest measurements 36½" after deep inspiration 38" after deep expiration 36 Cardiac response to effort 70 84 72 E T T 1 Breath sounds rather distant with a few indefinite crepitations at the left apex there is also a soft diastolic murmur heard t the apex of the heart but not in the aortic or pulmonary areas

X ray Examination (Plate XX) Lung fields normal except for some honey combing over the lower halves

COMMENT To illustrate the remarkably fe v abnormal shadows and slight disability after 46 years steel moulding

Case (10). Steel Moulder 24 years.

Age 38 years X-ray No 1188

Occupational History Left school at 14 years of age and immediately became an apprentice moulder and has worked at the job ever since (24 years)

Family History Nil relevant

Previous Health No serious illness

Present Health Good, no cough or shortness of breath but brings up black sputum after work, non-smoker

On Examination General nutrition good Chest measurements 36", after deep inspiration 37", after deep expiration 35½" Cardiac response to effort 68 64· 60 E T T 1 No abnormal physical signs over lung fields except that the breath sounds are rather distant, no abnormal signs in the cardiac or other systems

X-ray Examination (Plate XXI) Reticulation over both lung fields, calcified node right lower lobe

COMMENT Well marked reticulation after 24 years exposure (compare Cases 6, 7 and 8) suggesting that personal factors and not only the length of exposure or age play a part in the development of abnormal X-ray shadows

Case (11). Steel Furnaceman 27 years

Age 53 years X ray No 1275

Occupational History Left school at 13 years of age Gardening 7 years, building trade (plasterer 4 years fitter 1 year) 5 years, then furnaceman in steel foundry (27 years)

Family History Ten children, 1 died from tuberculous peritonitis at the age of 15

Previous Health Right empyema at 7 years of age Appendicitis at 19 years of age Cough and sputum for many years

Present Health Still has cough and sputum but no dyspnoea

[illegible] good Chest measurements 37", after deep [illegible] to effort 64 80

[illegible] ne indefinite crepita- [illegible] putum examination – no T B seen and no *iron containing phagocytes*

X-ray Examination (Plate XXII) Right diaphragm about ½" higher than the left Early reticulation throughout both lung fields

COMMENT Early reticulation without disability after 27 years as a steel furnaceman Some of the abnormal shadows probably due to siderosis

Case (12) Slinger in Moulding Shop 31 years

Age 61 years X ray No 1299

Occupational History Left school at 12 years of age Farm work shepherd and log cutter for 18 years then to a steel foundry as a slinger in the moulding shop (31 years)

Family History Nil relevant

Previous Health No serious illness

Present Health Slight cough with black sputum but no dyspnoea no clinical examination sputum examination no T B seen but many intra cellular iron particles found

X ray Examination (Plate XXIII) Reticulation both lung fields with calcified nodular opacities at the left hilum extending to the left upper lobe a few scat tered calcified nodules also in the right lung ?Healed Tb

COMMENT Healed tuberculosis and X ray reticulation in a steel moulding shop labourer

Case (13) Bricklayer's Labourer in Steel Foundry

Age 54 years X ray No 1280

Occupational History Left school at 14 years of age Farm labourer 4 years Bricklayer (houses) 5 years Blast furnace labourer 4 years Army service 6 months Steel rolling mills labourer 1½ years Then to a steel foundry as a bricklayer s labourer (23 years)

Family History Nil relevant

Previous Health Occasional attacks of influenza in the last few years Sus tained a compound fracture of the thigh at 32 years of age

Present Health Somewhat short of breath for the last two or three years Complains of cough and sputum in the mornings

On Examination General nutrition moderate Coarse tremor of hands and head Short of breath at rest Chest measurements 35 after deep inspiration 36½" after deep expiration 34¼" Cardiac response to effort 72 80 80 E T T 2 No definitely abnormal physical signs over the lung fields Heart nil Pupils equal and react to light and accommodation Romberg s sign negative Thyroid gland not enlarged No Parkinsonism Sputum examination no T B seen but contains intra cellular iron particles

X ray Examination (Plate XXIV) Generalised reticulation with some nodu lation in upper and lateral areas

COMMENT Probable early silicosis in a steel foundry bricklayer s labourer

Case (14) Pattern Maker 17 years

Age 39 years X ray No 1266

Occupational History Left school at 14 years of age Butcher s boy 1 year Then became apprenticed as a pattern maker and has worked at the trade all the rest of his working life (17 years)

Family History Nil relevant

Previous Health Had nephritis seven years previously No other illness

Present Health Fairly good Occasional cough and sputum in the mornings No clinical examination Sputum examination no T B or iron containing phagocytes seen

X ray Examination (Plate XXV) Early reticulation throughout both lung fields

COMMENT To show the abnormal shadows which are sometimes found in pattern makers who are mainly exposed to wood dust

Case (15) Pattern Maker 15 years

Age 34 years X ray No 1267

Occupational History Left school at 14 years of age Errand boy 2 years Apprentice pattern maker 6 years Out of work 2 years Docks crane driver 2 years Joiner 4 years Then to a steel foundry as a pattern maker (total years in a steel foundry 15)

Family History Nil relevant

Previous Health No serious illness

Present Health No cough sputum or dyspnoea No clinical examination

X ray Examination (Plate XXVI) Early reticulation both lung fields

COMMENT Slightly abnormal X ray changes in a pattern maker after 15 years exposure to wood dust (Compare Case 14)

Case (16). Electric Welder in Steel Fettling Shop 14 years.

Age 46 years X-ray No 1147.

Occupational History Left school at 14 years of age Blacksmith 12½ years Army service 3½ years Then to a steel foundry where he has worked in the fettling shop for 14 years

Family History. Nil relevant

Previous Health Good

Present Health Slight cough Red sputum but no dyspnoea No clinical examination Sputum examination no T B seen but sputum contains phagocytes with iron particles in them

X-ray Examination (Plate XXVII) Generalised reticulo-nodulation over both lung fields

COMMENT. Typical "welder's lung" Most of the shadows probably due to deposits of iron oxide in the lung (siderosis) but because of exposure to the dust of free silica in the fettling shop, slight silicosis in addition might be present

Case (17). Steel Dresser for 32 years.

Age 46 years X-ray No 1102

Occupational History Left school at 13 years of age and immediately began fettling castings at a steel foundry and has worked in the same shop ever since except for 3½ years service in the 1914 – 18 war

Family History Nil relevant

Previous Health Good

Present Health Complains of lassitude, pains in the shoulders, cough, copious sputum and pronounced shortness of breath

On Exam [illegible]

when rest of the lungs "silent" Post tussic crepitations both bases

X-ray Examination (Plate XXVIII) Reticulo nodulation both lung fields Nodulation more marked in upper lateral zones

COMMENT. Reticulo-nodulation in a steel fettler after 32 years with some disability diagnosis of silicosis made

Case (18). *Steel Dresser for 35 years*

Age 61 years X-ray No 1162

Occupational History Left school at 14 years of age and came straight to a steel foundry where he has worked ever since, first as a fettler and welder and later was a crane driver in the fettling shop for about 10 years He saw service both in the South African and 1914 – 1918 wars Apart from this he has spent all his working life at the one foundry

Family History Nil relevant

Previous Health Fractured pelvis and dislocated hips 17 years previously He was unable to walk for 7 years and is now lame

Present Health Has had a *winter cough which has been worse for the last three* years Brings up some sputum and is moderately short of breath

On Examination General nutrition fair Chest measurements 37½", after deep inspiration 38", after deep expiration 36½" Cardiac response to effort and E T T *not taken owing to lameness Movement of chest restricted, percussion note* impaired upper halves both lungs, post tussic crepitations both apices, more marked on the left side with numerous high pitched rhonchi over both lung fields Heart rate rapid (102) but no murmurs

X-ray Examination (Plate XXIX) *Marked nodulation both lung fields, the* nodulation being more marked in the upper lateral areas

COMMENT Well marked silicosis in a steel fettler – 35 years exposure

Case (19) Steel Dresser 23 years

Age 43 years X ray No 1098

Occupational History Left school at *13 years* of age, baker *5 years, gas works*
here he has worked
t steel dressing

Family History Nil relevant

Previous Health Pneumonia 12 months previously

Present Health Says that he went down every year with 'flu' while he was working at the annealing stove He has for a long time been subject to 'bronchial colds"

Present Health Cough and sputum each morning but does not feel short of breath normally

401"

tussic crepitations

X ray Examination (Plate XXX) Nodulation evenly distributed over both lung fields

COMMENT Silicosis in a steel dresser with 23 years exposure (Compare cases 6 7 and 8, steel moulders with equal length of exposure)

Case (20) Steel Fettler 24 years

Age 43 years X ray No 1085

Occupational History Left school at 13 years of age Telegraph messenger for 3 years Garage hand 1 year R A F 2 years Then to a steel foundry as dresser of steel castings

Family History One daughter who at 5 years of age had cerebro spinal menin gitis No family history of tuberculosis

Previous Health Two bouts of influenza but no other serious illness

Present Health Slight cough occasionally with whitish sputum but not notice ably short of breath

On Examination General nutrition good Chest measurements 36" after deep inspiration 37", after deep expiration 35½" Cardiac response to effort 68 96 76 E T T 1½ Chest movement moderate only abnormal signs were distant breath sounds with post tussic crepitations at the bases Sputum examination – no T B seen no iron containing phagocytes found in sputum

X ray Examination (Plate XXXI) Reticulo nodulation over both lung fields nodulation being present in the upper lateral zones

COMMENT Silicosis in a steel dresser after 24 years exposure slight disability

Case (21) Steel Fettler 31 years

Age 45 years X ray No 1090

Occupational History Left school at 14 years of age came to Factory M as a steel dresser and has done no other job

Family History Nil relevant No history of tuberculosis

Previous Health No serious illness

Present Health Slight cough and occasional morning sputum Says that his wind is not as good as it was but feels very fit

[illegible]

at the bases

X ray Examination (Plate XXXII) Nodulation and massive shadows both lung fields more marked in upper 2/3 Apices clear

COMMENT Advanced silicosis in a steel dresser after 31 years exposure This man was still working and not aware that his lungs were affected His tolerance to exercise was diminished

Case (26) Electric Welder in Steel Fettling Shop 23 years

Age 47 years X ray No 1151

Occupational History Left school at 14 years of age errand boy 2 years blacksmith s striker 2 years then to steel foundry where he worked as a steel fettler for 6 years and then as an electric welder for 23 years in fettling shop

Family History Nil relevant

Previous Health Has been troubled with indigestion for 8 years No other illness

Present Health Has slight cough no expectoration and is not short of breath

On Examination General nutrition fair a thin man chest measurements 33 after deep inspiration 35" after deep expiration 32½" Cardiac response to effort 64 78 64 E T T 1 Chest movements good breath sounds distant over both bases with indefinite post tussic crepitations

Sputum Examination No T B seen no iron containing phagocytes

X ray Examination (Plate XXXVII) Well marked nodulation over both lung fields

COMMENT Welders siderosis with possible silicosis 23 years exposure (Compare Case 16)

Case (27) Iron Moulder 38 years

Age 51 years X ray No L/4352

Occupational History Left school at 13 years of age and became an apprentice iron moulder and then an iron moulder in three foundries in the Midlands no other job

Previous Health Always healthy until 3 years ago when he began to suffer Was examined at a Tuber and he was advised to give full of dust

h scanty m co

breath sounds wheezy and prolonged especially over clinical diagnosis made of chronic bronchitis and emphysema

X ray Examination (Plate XXXVIII) Finely stippled background with reticulation and some nodulation over both lung fields

COMMENT Probable early silicosis in an iron moulder w th 38 years exposure

Case (28) Iron Moulder 38 years

Age 52 years X ray No L/4578

Occupational History Left school at 14 years of age became an iron moulder and has worked at the job ever since mainly at two factories in the Midlands

Family History Nil relevant

Previous Health Operation for stones in the right kidney in 1914 Left sided pleurisy in 1925

Present Health For the past year has had a persistent cough with morning sputum together with some shortness of breath after moderate exercise no loss of weight appetite good had to give up work on account of pains in the back

On Examination No definitely abnormal physical signs in heart lungs abdomen

X ray Examination (Plate XXXIX) Scoliosis heart long and narrow the right diaphragm higher than left generalised reticulation over both lung fields more marked in right middle zone where there is also nodulation occupying about two rib spaces some nodulation also in left middle zone and in upper lateral areas

COMMENT Silicosis in an iron moulder of 38 years exposure

Case (29) Iron Fettler and Grinder 22 years

Age 39 years X ray No L/4335

Occupational History Left school at 13 years of age riveter in spade and shovel works for 3 years iron grinder and fettler 22 years (1924 46) Works in the dressing shop and receives iron castings from the foundry brushes adherent sand off castings with wire brush and then grinds off rough metal with emery and carborundum wheels

Family History Nil relevant

Previous Health Pneumonia in 1931 away from work for 8 weeks

Present Health For 3 months has had cough with black sputum streaked with blood shortness of breath on exertion has been below par for 1 year

On Examination General nutrition good no clubbing of fingers no cyanosis square chest with some retraction at apices fair expansion percussion not slightly impaired both apices and in interscapular region breath sounds vesicular with a few scattered rhonchi crepitations and some friction at bases in front and in right axilla

X ray Examination (Plate XL) Reticulo nodulation both lung fields

COMMENT Silicosis or mixed dust pneumoconiosis with disability in an iron grinder and fettler

Case (30) Grinder of Iron Castings for 16 years.

Age 33 years X ray No L/4349

Occupational History Left school at 14 years of age, assistant caster for 2 years, then worked at the same iron works as grinder of iron castings for 16 years (1920 – 1936) All grinding was done on an emery wheel no sandstones used, castings not barrelled before grinding

Family History Nil relevant

Previous Health Pneumonia at 14 years of age (2 months illness), pleurisy at 28 years of age (3 weeks illness)

Present Health Became ill with right sided pleurisy 6 weeks before examination, no cough, occasional sputum no loss of weight

X ray Examination (Plate XLI) Reticulo nodulation both lung fields, large shadows both hila peaking and blurring of right diaphragm

COMMENT Silicosis or mixed dust pneumoconiosis in an iron castings grinder – emphysema also present

Case (31) Iron Dresser for 43 years

Age 58 years X ray No L/4350

Occupational History Left school at 13 years of age, 8 years apprentice iron dresser, 8 years iron dresser 4 years Army Service no illness or wounds 18 years iron dresser, 7 years iron dresser at another iron foundry for 2 years of which he did occasional shotblasting

Family History Nil relevant

Previous Health No serious illnesses fractured sternum 2 years ago (off work 3 weeks)

Present Health Has not felt well for 6 months complains of cough with blood streaked sputum and dyspnoea on exertion

On Examination General nutrition fair congested facies slight cyanosis flat chest with shallow movement percussion note somewhat impaired over all lung fields, breath sounds weak vesicular no crepitations

X ray Examination (Plate XLII) Fine generalised reticulation both lung fields, some nodulation in upper lateral areas

COMMENT Probable silicosis or mixed dust pneumoconiosis with disability

Case (32) Iron Dresser 26 years

Age 43 years X ray No L/4340

Occupational History Left school at 14 years of age, 4 years apprentice iron dresser 5 years Army Service 22 years iron dresser In the dressing of iron castings he used a pneumatic hammer (this is unusual in an iron foundry).

Family History Two brothers died from pulmonary tuberculosis

Previous Health No serious illnesses

Present Health For the past two years has felt short of breath with slight cough but no sputum Also during past two years has complained of stomach pains, investigation in hospital of alimentary tract revealed no abnormality Had to give up work on account of dyspnoea

On Examination Chest moves freely percussion note rather boxy especially at the apices and bases breath sounds shallow vesicular with some scattered rhonchi especially over left upper lobe no crepitations

X ray Examination (Plate XLIII) Reticulo nodulation both lung fields, large root shadows

COMMENT Probable mixed dust pneumoconiosis with marked disability

Case (33) Grinder and Fettler of Iron Castings for 38 years

Age 54 years X ray No L/4345

Occupational History Left school at 14 years of age 9 years fettler of iron castings (with wire brush) 2 years Army Service (gun shot wounds of left leg), 29 years grinding of malleable iron castings

Family History Nil relevant

Previous Health No serious illness

Present Health For the past 4 years has suffered from attacks of bronchitis but seldom lost more than 2 or 3 days work For the past year has had continual cough with sputum and shortness of breath with some loss of weight

On Examination Barrel shaped chest slight kyphosis percussion note resonant, breath sounds harsh vesicular with scattered rhonchi

X ray Examination (Plate XLIV) Generalised reticulo nodulation with discrete hard nodular shadows in right mid zone

COMMENT Probable silicosis or mixed dust pneumoconiosis with disability

Case (34). Dresser (Barreller) of Iron Castings for 16 years.

Age 44 years X-ray No L/4337

Occupational History Left school at 13 years of age, 2 years apprentice shoeing-

castings

Family History Nil relevant

Previous Health Healthy apart from occasional attacks of colds and influenza

Present Health Stopped work 6 months ago on account of cough with black sputum, dyspnoea and loss of weight

On Examination General nutrition fair, dyspnoea at rest, no definitely abnormal physical signs in the chest

X-ray Examination (Plate XLV) Small heart, dense root shadows, generalised reticulo-nodulation

COMMENT Silicosis or mixed dust *pneumoconiosis with marked disability*

Case (35). Grinder of Iron Castings for 22 years

Age 47 years X-ray No L/4330

Occupational History Left school at 13 years of age, 7 years drop forge stamping, 2 years Armed Forces, 2 years drop forge stamping, 4 years unemployed, then to iron foundry where he worked for 22 years as a grinder of malleable iron castings For the first 3 years he used sandstone grinding wheels and after that artificial wheels

Family History Nil relevant

Previous Health No serious illnesses

Present Health For 5 months has complained of cough, shortness of breath and pains in the chest, recent haemoptysis

On Examination General nutrition fair, chest moderate expansion, percussion note resonant, breath sounds quiet vesicular, no adventitious sounds

X-ray Examination (Plate XLVI) Trachea slightly displaced to right, generalised reticulo nodulation with opacity right sub clavicular region (? Tb)

COMMENT Silicosis (or mixed dust pneumoconiosis) with tuberculosis

Case (36). Grinder of Iron Castings for 21 years.

Age 41 years X ray No L/4332

Occupational History Left school at 13 years of age, 2 years edge tool polishing, 11 years grinder of iron castings – sandstone wheel, 10 years grinder of iron castings with emery wheel

Family History One brother has tuberculosis and silicosis (Case 35)

Previous Health Pleurisy at 17 years of age

Present Health Three years ago developed cough with haemoptysis, admitted for observation to sanatorium, sputum always negative for tubercle bacilli, discharged after 6 months

On Examination Gene...
note resonant,
rhonchi

X ray Examination (Plate XLVII) Generalised ground glass appearance over both lung fields with ill defined nodulation Opacity right sub-clavicular area (query quiescent Tb) ... scattered

COMMENT Silicosis (or mixed dust pneumoconiosis) with tuberculosis (Compare Case 35 – brother who worked in same factory)

Case (37) Grinder of Iron Castings for 11 years

Age 36 years X ray No ...

Occupat...

F... ...elevant

Previous Health No serious illness

Present Health Two years ago developed cough sputum ...

On Examination Gene...
general ...
chest

X-ray Ex... (Plate XLVIII) Generalised reticulo nodulation

COMMENT Mixed dust pneumoconiosis (or silicosis) with disability

Case (38) Grinder of Iron Castings for 16 years

Age 36 years X ray No L/4351

Occupational History Left school at 14 years of age, 2 years office boy, 3 years grinder of malleable iron castings 3 years Army Service discharged with rheumatism , 13 years grinder of malleable iron castings always used artificial wheels

Family History Nil relevant

Previous Health Good apart from rheumatism during Army Serv...

Present Health About two year...
on exertion with s...
with diagnosis of
for T B

On Examination ...ished movement of chest, percussion note resonant, breath sounds feeble vesicular but no added sounds

X ray Examination (Plate XLIX) Boot shaped heart, generalised reticulo-nodulation

COMMENT Silicosis (or mixed dust pneumoconiosis) with disability

Case (39). Sand and Shotblaster in Iron Foundry for 15 years.

Age 29 years X-ray No L/4346

Occupational History Left school at 14 years of age, 2 years labouring at tool making factory, 5 years sandblasting (cycle frames), 1 year unemployed; 6 years sand and shotblasting (iron stove grates) In all, sandblaster 9 years shotblaster 6 years

Family History One brother, a sandblaster died from silicosis at 30 years of age

Previous Health Fractured skull 2 years ago Good recovery

Present Health Nine months ago was taken to hospital with an acute attack of pneumonia Since then has had cough, sputum and dyspnoea on the least exertion Unable to work

On Examination General nutrition fair, percussion note resonant, breath sounds quiet vesicular with occasional fine crepitations at the bases

X ray Examination (Plate L) Well marked nodulation both lung fields

COMMENT Silicosis with disability

Case (40) Iron Moulder for 30 years

Age 47 years X ray No L/4571

Occupational History Left school at 14 years of age, 3 years apprentice iron moulder, 4 years Army Service, 27 years iron moulder

Family History Nil relevant

Previous Health No serious illnesses

Present Health For about 8 years has complained of lassitude, loss of appetite and shortness of breath with cough and sputum, sent to a tuberculosis dispensary for investigation *no tuberculosis found*

On Examination Big gaunt tired man free movement of chest, percussion note resonant, breath sounds weak vesicular, no added sounds

X ray Examination (Plate LI) Generalised reticulo nodulation

COMMENT Silicosis with marked disability

SUMMARY AND CONCLUSIONS

In Chapter IX the available facts about lung disease in foundry workers are discussed in detail A shorter summary of the main conclusions is given below —

1 A review of the published work relating to the health of foundry workers shows that in most foundry occupations the workers are exposed in varying

2 The present report includes

(i) the results of clinical and radiographic examinations of 3 059 workers (2 815 men and 244 women) in 19 foundries (iron steel and mixed iron and steel) (Chaps IV VI VII and X)

(ii) an analysis of the records of lung disease in foundry workers in the files of the Factory Department and the Silicosis Medical Board (Chap VI)

(iii) a study of the pathology of 64 deceased foundry workers (Chap V)

(iv) dust surveys in three foundries (Chaps VII and VIII)

(v) descriptions of foundry processes in general (Chap II)

(vi) descriptions of the methods of investigation (Chap III)

3 The appearances in the chest radiographs were classified for statistical

Statistical Analyses

4 Statistically it was shown that there is a greater risk of the occurrence of severe X ray abnormalities in steel foundry workers with the exception of labourers than in those who work in iron or mixed iron and steel foundries (Chap IV)

5 As regards the occupational groups it was demonstrated that workers in steel fettling shops are liable to develop more severe X ray abnormalities than workers in any other foundry occupation (Chap IV)

6 In general it was shown that in moulding and fettling shop occupations X ray classification is related to the type of exposure (Chap IV)

7
simila
each
th- st
moul
labour-rs (Chap IV)

The following significant observed/expected ratios for X ray Group II shows the relative liability of workers in the occupations named to develop early X ray reticulation in those occupations for which reasonable data were available

Occupation	*Type of exposure*	*Deviation of ratios from* 100	*Deviation ÷ standard error*
Moulders etc	Steel	48±16	2 9
Moulding shop labourers etc	Mixed	82±33	2 5
Knock-out men etc	Steel	60±28	2 1
Pattern shop workers	Mixed	—75±29	—2 6
Maintenance workers	Steel	—47±21	—2 2

The first 3 groups show a higher incidence of early reticulation whereas the last 2 (with ratios less than 100) show a lower incidence than the aggregate experi[illegible] (Chap IV)

8. [illegible]

showe[illegible]

occupational subdivisions were studied a

the subdivisions and the main groups c

(Chap IV)

The following significant observed/expected ratios were obtained for X-ray *Groups III and IV combined*

Occupation	*Type of exposure*	*Deviation of ratio from* 100	*Deviation ÷ standard error*
Fettlers	Steel	211 21	10 2
Welders etc	Steel	261 +31	8 5
Mixed occupations in fettling shop	Steel	179+35	5 1
Mixed occupations in moulding shop	Iron	—55±25	—2 2
Moulders etc	Iron	—36±15	—2 5
Coreshop workers	Mixed	—77 .34	—2 3
Coreshop workers	Iron	—100±42	—2 4
Pattern shop workers	Mixed	—100±35	—2 8
Maintenance workers	Mixed	—89±35	—2 7
Maintenance workers	Iron	—100±40	—2 5

groups of workers concerned

9 No useful correlation was found between exercise tolerance tests (which estimated the cardiac response to effort) and abnormal X ray appearances (Chap IV)

10 It was found that vital capacity is more closely related to age than to length of exposure to foundry work

11 [illegible]

showed reticulation or nodulation was less likely to have had an attack of pneumonia than another who showed less severe changes (Chap IV) Studies of the pathology of foundry workers lungs suggested that pneumonia is not the most common immediate cause of death amongst them (Chap V) As regards pleurisy our figures suggested that the trends are in contrast with those of pneumonia but the data are too scanty to enable valid conclusions to be drawn (Chap IV)

12 *Symptoms and Physical Signs* (*Chap IV*)

(i) No clear relationship existed between the symptom of cough and the X ray appearances of foundry workers chests

(ii) Expectoration was usually though not necessarily associated with cough The colour of the sputum was related to the colour of the dust inhaled Iron-containing phagocytes were found in the sputa of certain types of foundry workers who inhale iron dust In some workers with siderosis *iron containing phagocytes were not found*

(iii) The incidence of dyspnoea was higher in fettling shop workers than in other groups This was probably related to the higher incidence of silicosis amongst them

(iv) Men who had an X ray picture of reticulation were not usually disabled though a small proportion of them had some degree of disablement [illegible]

(v) The symptom of dyspnoea was not a reliable guide to the presence or absence of silicosis in its early stages

(vi) Chest expansion which decreases with increasing age also decreases with increasing fibrosis of the lung

(vii) A man can have an X ray picture of early or definite reticulation and yet present no abnormal physical signs on physical examination

(viii) [illegible] *reticulation nodulation or early massive shadows*

13 *Pathology* (*Chap V*)

(i) [illegible]

by the inhalation of mixed dusts containing free silica and other dusts such as iron oxide which tends to retard the development of classical silicosis

(ii) The most common complication of silicosis and mixed dust pneumoconiosis was tuberculosis Other complications were emphysema (bullous and focal), bronchial carcinoma and pneumonia

(iii)

On the whole the lungs of moulders tended to contain more silica and less iron than those of fettlers

(iv)

pneumoconiosis

14 *Records of lung disease* (Chap VI)

Analysis of the records of the Silicosis Medical Board and the Factory ... has been found ... and grinders, ... rs Silicosis ... tylene) who ... r in an iron ... knock-out

15 *Environmental*

(i) A dust survey with the thermal precipitator of the main operations proceeding in an iron foundry showed air borne dust cloud concentrations varying between 270 and 2,800 mineral dust particles per cc, with median dust cloud particle sizes between 0 25μ and 0 8μ Modification of foundry processes and attention to dust preventive measures reduced the dust counts to a range of 83–385 particles per cc, with a marked increase in the median sizes of the dust clouds remaining The great difficulties associated with the interpretation and evaluation of thermal precipitator and similar dust samples taken in iron (and steel) foundries ... ork in this field ... he iron foundry ... e of the workers ... p VII)

(ii) ... estimations in a steel foundry with the ... precipitator and ... borne dust con- ... The ... Serial ... were counts with the ... of dust concentrations in such a normally

Fettling work with pneumatic chisels (greatest risk)
Roughing out, wheelabrator and portable grinder work (all much the same risk)
Swing frame grinding work (low risk) (Chap VIII)

(iii) A note is added with photographs of the dust clouds, of the results of a series of Owen's dust counter samples taken in steel foundry M A marked difference existed between the concentrations of dust particles in the moulding and fettling shops Clinical and X-ray examinations of the workers in the two shops showed differences in the incidence of lung diseases, roughly corresponding with the environmental conditions (Chap VIII)

16 *Sand or Shotblasters* (*Chaps I, IV, V VI, IX and X*)

(i) There is a risk of silicosis and/or tuberculosis to blasters of iron and steel castings whether the abrasive used is sand or shot

(ii) Statistical analysis shows that the risk is rather less in the blasting of iron castings than of steel castings

(iii) Cases of silicosis, though fewer in number, continue to occur amongst sand or shotblasters in spite of stringent regulations requiring dust control measures

(iv) In 21 sand or shotblasters the average age at death was 48 9 years, the average exposure being 13 years (shortest 3 years, longest 20½ years)

17. *Fettlers of Steel Castings* (*Chaps I, IV, V, VI IX and X*)

(i) Fettlers of steel castings are exposed to a serious risk of silicosis, often accompanied by tuberculosis This has been shown on statistical, clinical and pathological evidence

(ii) Well marked X ray reticulation appears after about 10 years exposure and nodulation after 15 years A diagnosis of silicosis can be made in the stage of reticulation when clinical evidence of disability is also present.

(iii) In a series of 21 deaths from silicosis in steel fettlers the average age at death was 53 4 years and the average duration of employment was 28 6 years (Shortest 10 years longest 44 years)

(iv) Fettling with the pneumatic tool appears to be the most dangerous method Hand fettling (with hammer and chisel) is much less dangerous

(v) There has been a steep increase in the number of cases of silicosis and tuberculosis in steel fettlers since 1931 and the increase is continuing. The main reasons for the increase are (1) that the dust from the process is not controlled, (2) that the pneumatic tool has replaced the hand hammer and chisel and (3) that the output of steel castings is increasing

(vi) Grinders of steel castings are not exposed to such a severe risk of silicosis as steel fettlers because most grinding processes have, by regulation, to be done under exhaust ventilation

18 *Fettlers of Iron Castings* (*Chaps I, IV, V, VI, IX and X*)

(i) Iron fettlers are exposed to the inhalation of dust which in some cases can cause typical silicosis but more often produces a modified silicosis or a mixed dust pneumoconiosis

(ii) The pneumoconiosis or modified silicosis of iron fettlers may be accompanied by tuberculosis or pneumonia, either of which conditions may be the immediate cause of death

(iii) The incidence of the pneumoconioses and their corresponding X ray shadows is lower in iron fettlers than it is in steel fettlers In spite of the lower incidence of lung disease in iron fettlers the risk should be recognised

(iv) There are three probable reasons why the incidence of X ray abnormalities and fibrosis of the lung is higher amongst workers in steel than in iron fettling shops

(a) The melting point of steel is higher than that of iron (1550° – [illegible]

castings

(b) The burnt on" sand is difficult to remove and pneumatic tools [illegible]

(c) [illegible] more free silica (SiO_2) than moulds for iron cast[illegible] moulding sand contains up to 99% of free silica whereas iron moulding sands rarely have more than 80% and usually have less

19 *Steel Moulders* (*Chaps I, IV, V, VI, IX and X*)

(i) [illegible] exposed to the inhalation of dusts which after a period [illegible]

(ii) If the moulding mixture used contains silica flour there is a greater risk of the moulders developing silicosis and 3 such cases were found in the present inquiry

(iii) Statistical analysis shows that the percentage incidence of X-ray abnormalities is greater amongst moulders in steel works than in iron or mixed iron and steel foundries This result is at variance with the detailed information about individual cases known to the Factory Department and the Silicosis Medical Board More cases of silicosis have been recorded in iron than in steel moulders

20 *Iron Moulders* (*Chaps I, IV, V, VI, VII, IX and X*)

(i) Iron moulders develop well marked silicosis and mixed dust pnuemoconiosis

(ii) [illegible] of silica parting powders has been mainly [illegible] ulders But it is [illegible] knock-out might [illegible]

(iii) Statistical analysis in the general investigation did not reveal a high [illegible]dence of X ray abnormalities amongst iron moulders

(iv) [illegible]

21 *Furnace Men* (*Chaps I, IV, IX and X*)

(i) Furnace workers, including casters, ladlemen, pourers cupola attendants and annealers, develop after some years abnormal X ray appearances due to the inhalation of dust

(ii) The abnormal changes are more pronounced in steel furnacemen than those in iron or mixed iron and steel foundries

(iii) It is probable that most of the abnormal X-ray changes are due to siderosis (a benign pneumoconiosis) but the possibility of mixed dust pneumoconiosis or even silicosis cannot be ruled out

22 *Knock out men, Sandmixers and Crane drivers* (*Chaps IV and IX*)

(i) In common with most other workers in steel foundries knock-out men sandmixers and crane drivers show a higher incidence of X-ray abnormalities than the comparable group in iron or mixed iron and steel foundries

(ii) The incidence of severe X ray abnormalities in the whole group is not high but the presence of milder degrees of abnormality indicates early silicosis or mixed dust pneumoconiosis

(iii) Men exposed to the inhalation of dust from the knock-out are liable to contract silicosis but not to the same extent or as rapidly as blasters and fettlers

(iv) The evidence as to the risk of silicosis and mixed dust pneumoconiosis in sandmixers is based solely on the results of X ray examinations

(v) The risk to crane drivers is apparently greater in the fettling shop than it is in the moulding shop In this group it is possible that some of the abnormal X ray shadows are caused by siderosis

23 *Moulding shop labourers* (*Chaps IV and IX*)

(i) Moulding shop labourers, slingers, truck drivers and internal dispatch men develop X-ray abnormalities due to dust inhalation

(ii) The incidence is significantly high for early reticulation (II) in mixed iron and steel foundries in this group For the severer forms of X-ray abnormality (reticulation and nodulation) the incidence is low in all three exposure groups

(iii) Definite silicosis has not been found in any man with a clear occupational history of having been only a moulding shop labourer

(iv) It is possible that the abnormal X-ray changes found might represent the early stages of silicosis, mixed dust pneumoconiosis or siderosis, but we have no pathological evidence to support or disprove the theory

24 *Welders* (*Chaps I, IV, V, VI, IX and X*)

[illegible]

25 *Coremakers and Coreshop Workers* (*Chaps IV, V, VI, IX and X*)

Coremakers and workers in the coreshop are exposed to a minimal risk of silicosis and mixed dust pneumoconiosis But if silica parting powders are used on the cores, the risk will be much the same as in iron moulders

26 *Pattern Shop Workers* (*Chaps IV, IX and X*)

Pattern shop workers show mild X ray evidence of dust inhalation but their health is affected very little and without pathological evidence it is not possible to be certain about the cause of the X ray shadows

27. *Maintenance and other workers* (*Chaps IV and IX*)

develop silicosis and one such case was found in our series

28. *Furnace Bricklayers and Dismantlers.* (*Chaps. I, VI and IX*)
This group is exposed to a definite risk of silicosis.

29. *Young Foundry Workers* (*Chaps IV and IX*)
Even after short exposures to foundry conditions young workers develop a high incidence of mild X-ray abnormalities The probable reasons for this finding are discussed.

30 *Tuberculosis* (*Chap IX*)
Amongst 2,767 male foundry workers there were 10 cases (0.36 per cent) of

31 *Cancer* (*Chap IX*)
ings we found 3 cases
survey we found no

32. *Preventive measures* are discussed (*Chap. IX*)

33 *Representative case histories* of iron and steel foundry workers are described in detail and illustrated with X-ray photographs (*Chap. X*)

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Glossary

It has been suggested that a short glossary of foundry and technical terms will be helpful to the general reader Statistical terms are not included in the glossary because most of them are explained in the text Definitions of some of the commoner medical terms are given

Acid Melting Processes The melting of steel in furnaces lined with siliceous materials

Basic Melting Processes The melting of steel in a furnace lined with a basic material (usually dolomite)

Binder Any substance which holds sand particles together so that they can be moulded into and retain any given shape, e g clay binder, oil binder, synthetic resin

Blast An air jet blown into a cupola or converter (q v)

Blasting The cleaning of castings by propelling sand or grit against them by means of a water or compressed air jet, or by a steam jet or by a wheel

— *cabinet* An enclosed cabinet in which blasting is done, the operator remaining outside

— *chamber* An enclosed chamber in which blasting is done by an operator inside

Bond See binder

Brushing Cleaning of castings with a wire brush

Casting The process of pouring molten metal into a mould (verb) The cooled and solidified metal taken from a mould (noun)

Chamotte A refractory material consisting of calcined aluminous fireclay

Chipping The cleaning of castings by means of a chisel, either hand or pneumatically operated

Clay Grade Dust Samples Samples of dust separated from bulk dust samples by elutriation and whose constituent particles are not larger than 10μ in diameter

Closing The fitting together of the various parts of a mould before casting

Collagen Fibre (Path) This is a stout connective tissue fibre staining yellow with silver impregnation methods Cf Reticulin fibre

Converter A pear-shaped vessel supported on trunnions in which molten iron is converted into steel by blowing air through, or on to it

Bessemer ——— A converter in which air is introduced through holes in the bottom

Tropenas ——— A converter in which the blast of air is introduced through holes in the side

Cope The top part of a moulding box

Core Sand rammed into the shape of the interior of a casting

— *binders* Compounds such as oil used to make the core sand grains adhere

Cupola A shaft furnace in which coke, limestone and iron are placed The furnace is fitted with tuyeres through which air for combustion is supplied under pressure The coke burns to melt the iron, whilst the lime forms the basis of a slag which removes impurities

Drag The bottom part of a moulding box

Dressing A term which includes all processes used in the cleaning of a casting after the knock-out (q v) Also called fettling

is suggested as an alternative

Dyspnoea Shortness of breath

Easing The breaking down of cores after casting to allow the cooling metal to contract freely and so to avoid cracking of the casting

Elutriation A method of separating dust suspended in a fluid into its component size ranges by carrying upwards in a fluid stream those particles which are too small to settle against the chosen velocity of the fluid

Emphysema Distension of the air cells of the lungs

Fettling See Dressing

Gates Passages in the sand mould through which the molten metal runs into the mould cavity

Gravimetric Sampling Methods Methods devised for removing sufficient air borne dust from known volumes of working atmospheres by suitable filters (e g a bed of salicylic acid crystals or an electrostatic precipitator) to enable the dust caught to be weighed on a (micro) balance and the mass of dust per unit volume of air calculated

Green Sand Sand containing about 5 per cent moisture

— *mould* Mould made of green sand into which the metal is cast without drying the sand

Grinding The removal of surface imperfections from a casting by pressing it against a revolving abrasive wheel

Hydroblast A chamber in which sand is removed from castings by projecting against them a stream of high pressure water and sand

Knock out The process of removing the mould and core sands and the casting from the moulding box

Ladle A steel container lined with refractory material and used to transport molten metal

Loam A strong sand mixture which often contains fireclay or ganister

Micron (μ) A convenient unit for measuring the sizes of particles in dust clouds or fine powders 1μ is a thousandth of a millimetre or a twenty five thousandth of an inch

Mixed Dust Pneumoconiosis (See Dust Reticulation)

Molochite A refractory material consisting of vitrified china clay

Mould The impression in the rammed sand into which molten metal is poured The term is also used to describe the box and the sand together

— *drier* A portable box containing a fire with a forced draught, used to dry big moulds

— *paints* Finely divided refractory materials suspended in a fluid and painted on to the mould surface

Moulding The process of making moulds

— *bench* The bench on which small moulds are made

— *box* The box in which the sand is rammed and the metal subsequently cast

— *machine* A machine for making moulds

— *pit* Pits in a moulding floor in which heavy moulds are made

— *sands* Silica sands with binding agents used for making moulds

Mucking-out The rough removal of sand adhering to a casting Sometimes called stripping or 'rough fettling'

Nodulation (X-ray) A pattern seen in X-ray films of the chest, consisting of numerous rounded shadows or nodules usually about 5 mm in diameter

Oil Sand Sand bonded with oil and used for making cores

Open Hearth Furnace A steel making furnace with an open hearth and regenerators to preheat air and gas for combustion May be acid or basic

Owen's Jet Dust Sampler An instrument for taking quick, nearly instantaneous [illegible]

Parting Sand Sand without a bonding agent used to place between two layers of bonded sand so that they will not adhere and can be separated at a later stage

— *powder* A powder used in the same way as parting sand and also sprinkled on patterns to prevent adhesion of the sand

Pattern A wooden or metal replica of a casting and round which sand is rammed to impart to it the desired shape

Pneumoconios [illegible] Th[illegible] shortened form of the orig[illegible]nal term [illegible]

made up of reticulin and collagen (q v)

Pouring Introducing molten metal into a mould See Teeming and Casting

Refractory High melting point material in which molten metal can be contained (e g silica sand ganister sillimanite zircon etc)

Reticulin Fibre (Path) This is a fine connective tissue fibre staining black with silver impregnation methods It may develop into collagen (q v)

Reticulation (X ray) A term which means a network used to describe a pattern of shadows seen in X ray films of the chest See also *dust reticulation*, a term used in pathology

Risers Columns of molten metal rising from a casting which provide a reservoir of molten metal to feed into the casting while it contracts on cooling. The term also refers to the openings through the sand mould made to contain the columns of metal

Rumbler A cylindrical rotating box in which light castings are cleaned by friction of the castings against each other when the box is rotated

Sand High silica refractory used for making moulds

Backing ——— Inferior quality sand used for the back of the mould and which does not come into contact with the molten metal

Dry ——— The sand composing a mould which has been dried before introducing the molten metal

Green ——— Sand containing about 5 per cent moisture A mould which has not been dried before introducing the molten metal

——— *blasting* The cleaning of castings by impingement of a stream of sand under pressure See Blasting

——— *slinger* A machine used to propel a stream of sand around a pattern to form a mould

Shotblasting The cleaning of castings by propelling a stream of metal shot against them (See Blasting)

Sidero Silicosis Pneumoconiosis due to the inhalation of a *mixture of iron* and silica (SiO_2) dust

Siderosis

Silica, amorphous Non-crystalline forms of silica, such as kieselguhr

Silica Flour Free silica (SiO_2) or quartz which has been ground into a fine powder

Silica, free Silicon dioxide, SiO_2 not chemically combined with anything else Common forms are quartz, flint, sand rock crystal, chert diatomite, chalcedony, etc

Silica hard free Many but not all compounds of silicon can be separated from quartz by treatment with fluoboric acid Quartz and all the silicon compounds that are not removed by fluoboric acid are known as ' hard free silica

Silica total The sum of free silica and combined silica, the latter term denoting silica which is chemically combined with other elements in the various siliceous materials, as in silicates

Silicosis A form of fibrosis of the lungs due to the inhalation of the dust of free silica (SiO_2) characterised by the presence of whorled nodules in the lung tissue and by nodular (and sometimes reticular) shadows on the X ray film of the chest

Silico Tuberculosis (Path) This is a form of silicosis accompanied by tuberculosis in which the lesion consists of mixed nodules of both tuberculous and silicotic elements

Sillimanite A refractory material composed of aluminium silicate

Silt Grade Dust Samples Samples of dust separated from bulk dust samples by elutriation, and whose constituent particles lie between 10μ and 100μ in diameter

Skin Dried Mould A mould made of green sand, the surface of which has been dried before introducing the molten metal

Methods ... the degree of sta ning produced on a filtering ... antities of the working ... of the amount of air

Stripping See Mucking out

Teeming Pouring molten metal into a mould

Thermal Precipitator The standard British instrument for long period sampling of air borne dust clouds, the dust particles being precipitated on to thin microscopic cover glasses which can subsequently be examined under ... and size

Tropenas Converter See Converter

Tuyeres Pipes through which air is introduced into a furnace or converter

Wheel Abrading Blasting (q v) in which the abrasive is propelled by the centrifugal action of a wheel

X ray Diffrac ... of X rays of

Zircon A refractory material composed of zirconium silicate

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We are much indebted to many firms and individuals for help in carrying out this investigation Unfortunately it is the wish of the managements of the 19 foundries which were visited during the field investigation that their names should not be mentioned but the willing help of the directors managers and workers often given at great inconvenience should be placed on record

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[illegible]

they were made

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S O Code No 3f 181*

CHEST RADIOGRAPHS

PLATES I–LI

Much help has also been received from Dr J L A Grout, M C, Hon Radiologist to the Sheffield Royal Infirmary and Hospital and from Dr H Midgley Turner, Chief Tuberculosis Officer for Sheffield

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CHEST
RADIOGRAPHS

PLATES I–LI

PLATE I

Chest Radiograph—Steel Fettler Case 11 Chap V.

Coarse nodulation and massive shadows upper two thirds both lungs
Clear areas lower thirds suggesting presence of emphysema

PLATE II

Chest Radiograph—Steel Fettler Case 13 Chap \ 19 7-40

Sh w ng d a n a h a r gh and peak ng of
be h l a d aph agn \ dula n er b h lung fi lds w th ma e
ha w n a un n upper and m ddl h rds be h lungs ng
haped hado ugg ng a a n a p r ph ry of l f mas e
had w ap ces ar

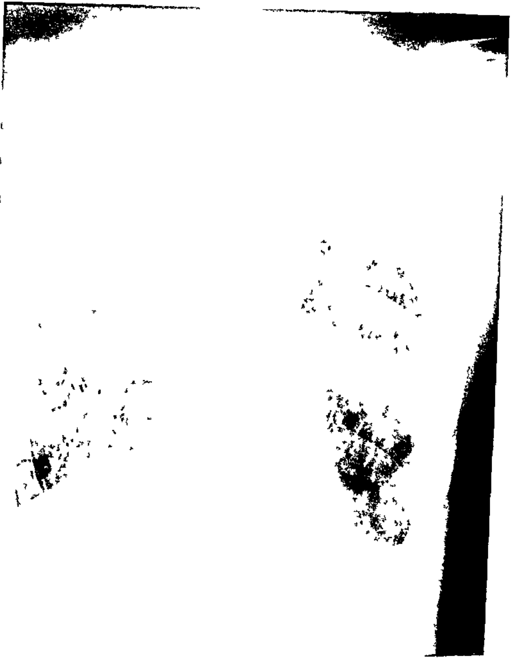

PLATE III

Same case as *Plate II* *Film taken 29 8 46*

Showing extension of massive shadows, cavitation in right upper but no definite evidence of cavitation on left

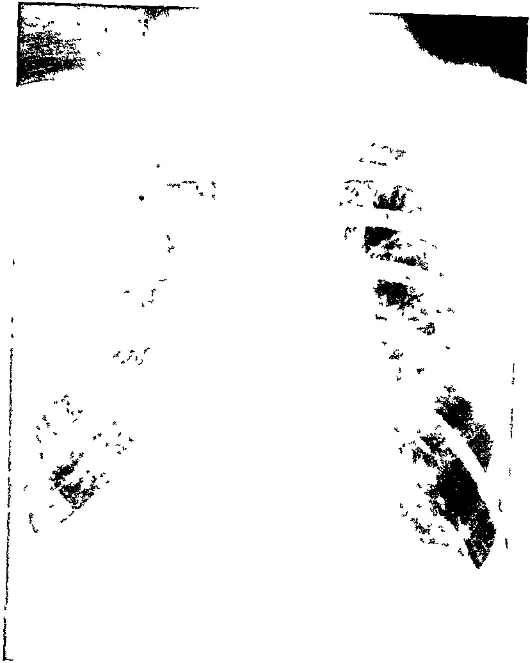

PLATE X

Chest Radiograph—Steel Fettler Case 19 Chap X 5 2 45

Fine generalised reticulo nodulation with conglomerate shadows in right midzone and both supra clavicular regions A few discrete nodules in both upper lateral areas

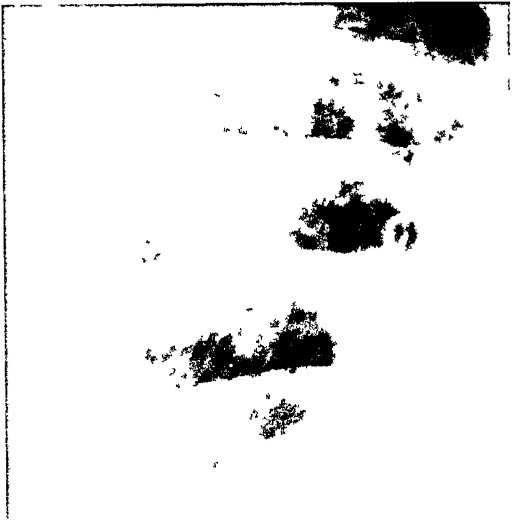

PLATE VII

Same case as Plate VI

Contact print actual [illegible] of right midzone showing nodular sh[illegible]

PLATE XIII

Chest Radiograph—Steel Moulder Case 2 Chap X

Some increase of linear shadowing but the picture is within normal limits

PLATE XVII

Chest Radiograph—Steel Moulder Case 6 Chap X

Slight reticulation

PLATE XVIII

Chest Radiograph—Steel Moulder Case 7 Chap X

Well marked reticulation

PLATE XX

Chest Radiograph—Steel Moulder Case 9 Chap X

Lung fields normal except for honeycombing lower halves

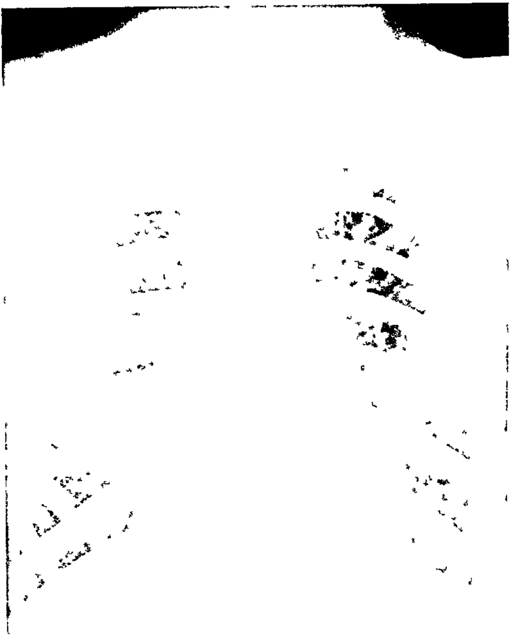

PLATE XXI

Chest Radiograph—Steel Moulder Case 10 Chap X

R[illegible]ula[illegible]n both lung fields

PLATE XXII

Chest Radiograph—Steel Furnaceman. Case 11 Chap X

Ret culat on both lung fi lds

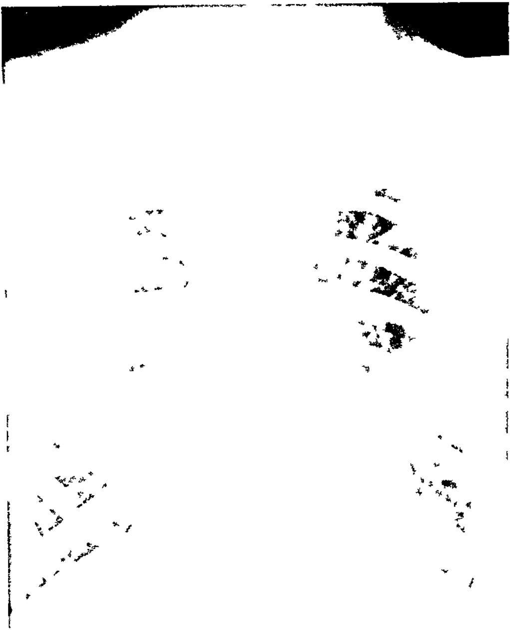

PLATE XXI

Chest Rad graph Steel Moulder Case 10 Chap X

R ula n bo h lung fie ds

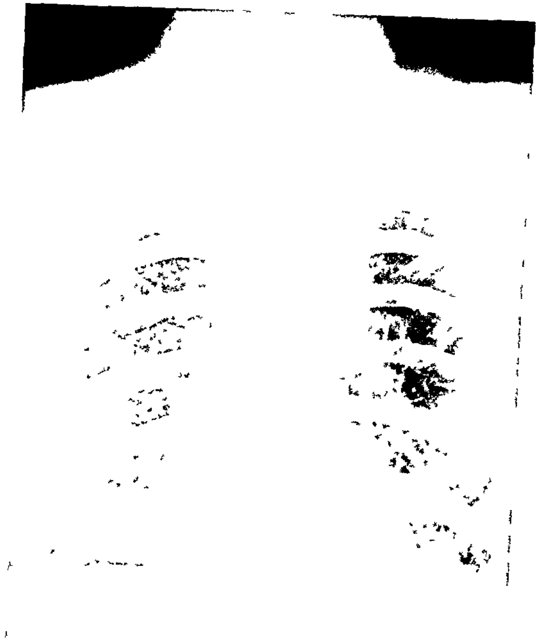

PLATE XXIII

Chest Radiograph—Slinger in Moulding Shop. Case 12
Chap X

Reticulation—calcified nodular opacities ? H and Tb

PLATE XXIII

Chest Radiograph—Slinger in Moulding Shop Case 12
Chap X

R ulat on—cal fied n dular opac t s ? H al d Tb

PLATE XXX

Chest Radiograph Steel Fettler Case 19 Chap X

W k

PLATE XXIX

Chest Radiograph—Steel Fettler Case 18 Chap X

W ll n k d n lula b th lung f ld

PLATE XXX

Chest Radiograph—Steel Fettler Case 19 Chap X

[illegible]

PLATE XXXI

Chest Radiograph—Steel Fettler Case 20 Chap X

Reticulo nodulation both lung fields nodulation being seen in upper lateral zones

PLATE XXXII

Che Rad graph Steel Fettler Case 21 Chap X

b hlu g fi ld emph rua bis
p l a

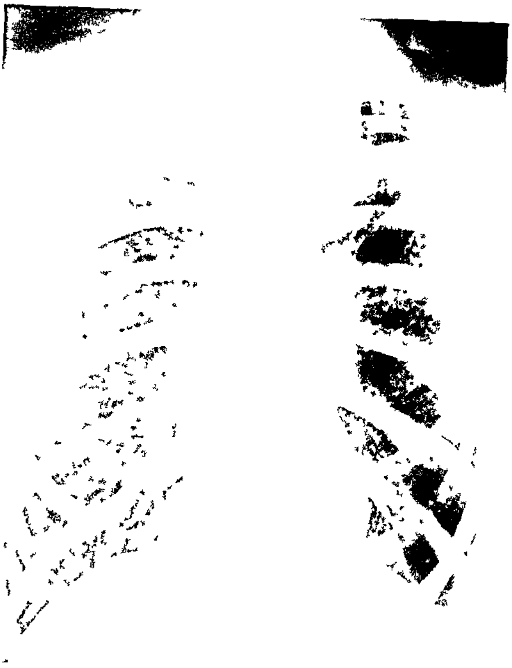

PLATE XXXIII

Ch Ra l graph Steel I ttler Ca e 22 Chap X

k n b h lun d

PLATE XXXIV

Chest Radiograph—Steel Fettler. Case 23. Chap. X.

Background of reticulation with emphysema at bases; massive shadows both upper lobes with signs of cavitation in left upper.

PLATE XXXV

Chest Radiograph—Steel Fettler Case 24 Chap X

Nodulation over lower two thirds of both lung fields ? emphysema at bases apices clear

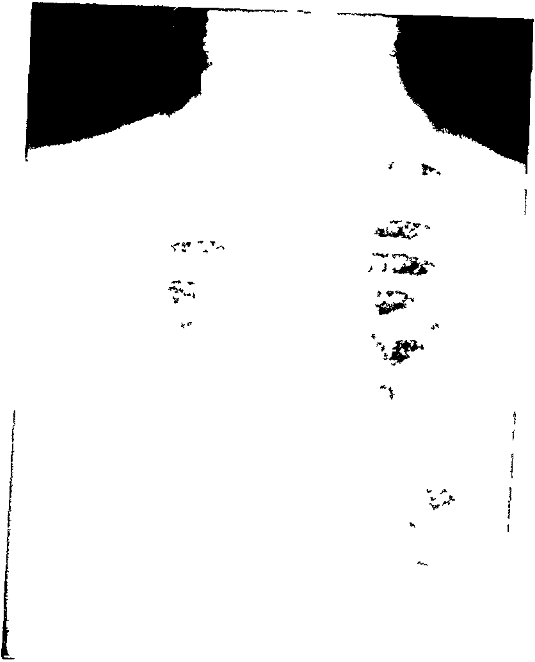

PLATE XXXVII

Welder in Steel Fettling Shop
Chap X

welder s s deros s w h

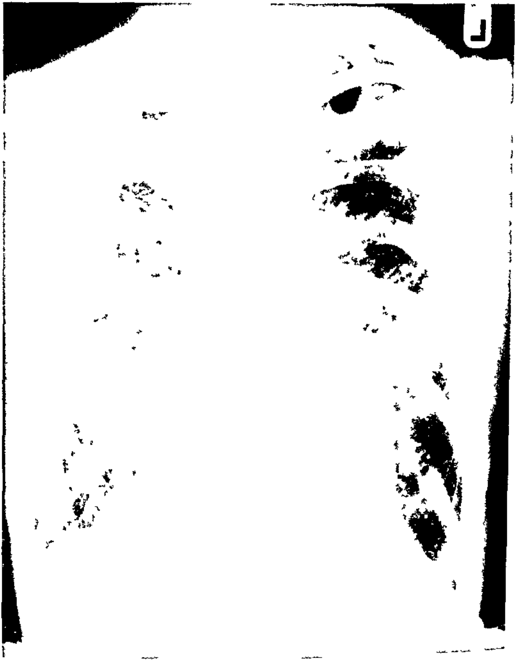

PLATE XXXIX

Chest Radiograph—Iron Moulder Case 28 Chap X

Generalised reticulation with some nodulation For fuller description see text

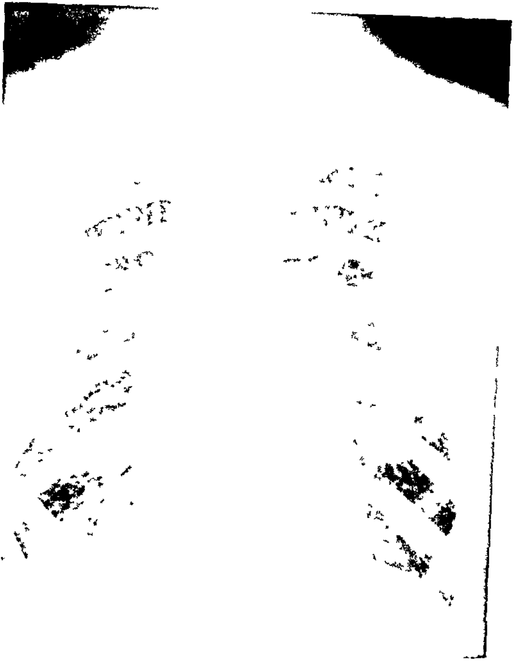

PLATE XLI

Chest Radiograph—Grinder of Iron Castings Case 30 Chap X

Reticulo nodulation both lung fields

PLATE XLII

Chest *Radiograph*—Iron Fettler Case 31 Chap X

Fine generalised reticulation both lung fields [illegible] nodulation in upper lateral area

PLATE XLIII

Chest Radiograph—Iron Fettler **Case 32 Chap X**

Ret ulo nodula n bo h lung fiel ts

PLATE XLIV

Chest Radiograph Grinder and Fettler of Iron Castings
Case 33 (Chap. X)

[illegible]

PLATE XLV

Chest Radiograph—Barreller of Iron Castings Case 34 Chap X

Generalised reticulo-nodulation dense root shadows

PLATE XLVI

Chest Radiograph—Grinder of Iron Castings (Case 35)
Chap. X

[illegible]

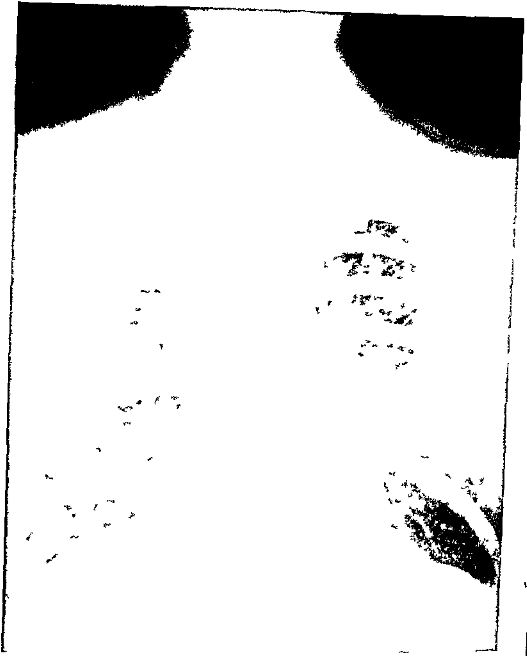

PLATE XLVII

Chest Rad ograph—Gr nder of Iron Cast ngs Case 36 Chap X

Ill defin d n dula n v r both lung fields opac v r ght sub la ular ar a qu c nt Tb

PLATE XLVIII

Chest Radiograph Grinder of Iron Castings Case 37
Chap X

[illegible]

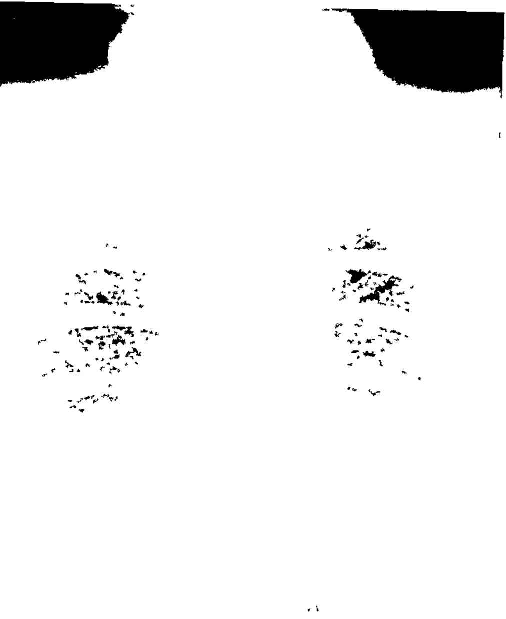

PLATE XLIX

Chest Radiograph—Grinder of Iron Castings Case 38 Chap X

Generalised reticulo nodulation

PLATE I

Chest Radiograph—Sand and Shotblaster in Iron Foundry
Case 39. Chap. X

Well marked nodulation both lung fields and increased hilar shadows.

PLATE II

Chest Radiograph—Iron Moulder Case 40 Chap X.

Generalised reticulo-nodulation